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TRENDS IN CRASHWORTHINESS OF THE NEW ZEALAND VEHICLE FLEET BY YEAR OF MANUFACTURE: 1964 TO 2002:

by

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Trends in crashworthiness of the New Zealand vehicle fleet by year of manufacture: 1964 to 2002

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Abstract:
Crashworthiness is an estimate of the occupant protection provided by a vehicle, namely the risk of a driver of a vehicle being killed or admitted to hospital when involved in a crash. The relationship was investigated between vehicle crashworthiness and both the year of manufacture and the year of first registration (in New Zealand) of New Zealand light passenger vehicles manufactured from 1964 to 2002 and crashing during 1991 to 2002. The latter analysis was aimed at assessing crashworthiness trends in the fleet of used imported vehicles in New Zealand whilst the former examined trends in the fleet as a whole. Crashworthiness was measured by a combination of injury severity (of injured drivers) and injury risk (of drivers involved in crashes). The ratings were adjusted for the sex and age of the driver, the speed limit at the crash location, the number of vehicles involved in the crash and the year in which the crash occurred. The crashworthiness rating estimates the risk of the driver being killed or admitted to hospital when involved in a crash, to a degree of accuracy represented by the confidence limits of the rating in each case.

Analysis of trends by year of vehicle manufacture showed statistically significant improvement in the crashworthiness of New Zealand light passenger vehicles over the years of manufacture studied. Most of the measured improvement occurred over the years of manufacture from 1983 to 2002. Over this period, the risk of death or serious injury to drivers reduced by around 50% for the fleet as a whole. During this period vehicle safety in New Zealand was affected by several competing effects: a general increase in both active and passive safety features in vehicles; increasing proportions of used imported vehicles entering the New Zealand fleet; and increases in the regulation of vehicle safety standards by the New Zealand Government.

Both the level of absolute crashworthiness and trends on a year of manufacture basis were similar for used imports to those for vehicles sold new in New Zealand. Estimates of crashworthiness trends in the used import vehicle fleet by year of first registration in New Zealand from 1978 to 1998 showed statistically significant improvements in crashworthiness over these years. Absolute levels of crashworthiness and improvements by year of first registration paralleled those seen in the analysis by year of manufacture but occurred some 6 years later, a lag equivalent to the average age of the used imported vehicles over the study period.

Key Words: (IRRD except when marked*)
Injury, vehicle occupant protection, collision, passenger car unit, passive safety systems, statistics

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EXECUTIVE SUMMARY

This report describes the development of New Zealand crashworthiness ratings by year of vehicle manufacture for 1964-2002 model vehicles. Crashworthiness ratings of vehicles by year of first registration in New Zealand were also examined, focusing primarily on the fleet of used imported vehicles sold in New Zealand. Crashworthiness ratings measure the risk of death or serious injury (hospitalisation) to drivers of vehicles involved in crashes. The estimates are derived from analysis of data on real crashes. The analysis in this study is based on data from police reports on injury crashes occurring in New Zealand during 1991-2002.

Crashworthiness is an estimate of the occupant protection provided by a vehicle, namely the risk of a driver of a vehicle being killed or admitted to hospital when involved in a crash. Crashworthiness is a measure of the occupant protection provided by a vehicle. The crashworthiness measure estimates the risk of a driver of a vehicle being killed or admitted to hospital when involved in a crash. It is obtained from the product of injury severity (of injured drivers) and injury risk (of drivers involved in crashes) for the drivers of vehicles of the specified year of manufacture or specified year of first registration in New Zealand. A new method of analysis has been demonstrated in the study that gives unbiased estimates of injury risk from injury crash data where the total number of uninjured drivers is unknown. The method was used separately to obtain crashworthiness for vehicles by year of manufacture and by year of first registration in New Zealand.

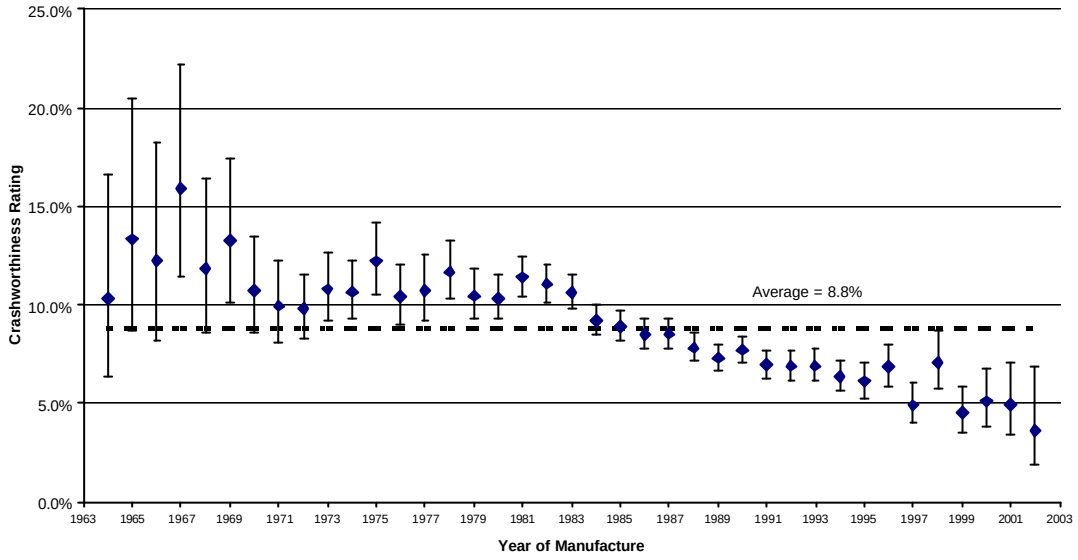
The injury risk estimates were based on crash data for 63,010 drivers involved in crashes between two vehicles in New Zealand during 1991-2002 where one or both drivers were injured and the vehicle was manufactured between 1964 and 2002. The injury severity estimates were based on crash data for 143,723 drivers injured in crashes in New Zealand during 1991-2002 and where the vehicle was manufactured between 1964 and 2002. For comparative purposes crashworthiness ratings were obtained separately for the total fleet, for vehicles sold new in New Zealand and for used imported vehicles.

The injury risk ratings were adjusted for the sex and age of the driver, the speed limit at the crash location and the year in which the crash occurred. The injury severity ratings were also adjusted for the number of vehicles involved in the crash. These factors are known to be strongly associated with injury risk and injury severity. Adjustments were made via logistic regression analysis techniques with the aim of measuring the effects of vehicle factors alone, uncontaminated by other factors available in the data that affected crash severity and injury susceptibility. The degree of accuracy of the crashworthiness ratings is represented by the confidence limits of the rating in each case.

Analysis successfully estimated trends in the crashworthiness of the light passenger vehicle fleet (cars, station wagons, four wheel drives, vans and utilities) in New Zealand by both year of manufacture and year of first registration in New Zealand. Estimates of crashworthiness by year of vehicle manufacture for the New Zealand light passenger vehicle fleet as a whole along with 95% confidence limits are shown in Figure E1. Analysis of trends by year of vehicle manufacture show statistically significant improvement in the crashworthiness of New Zealand light passenger vehicles over the years of manufacture studied. The majority of the measured improvement occurred over the years of manufacture from 1983 to 2002. Over this period, the risk of death or serious injury to drivers in a

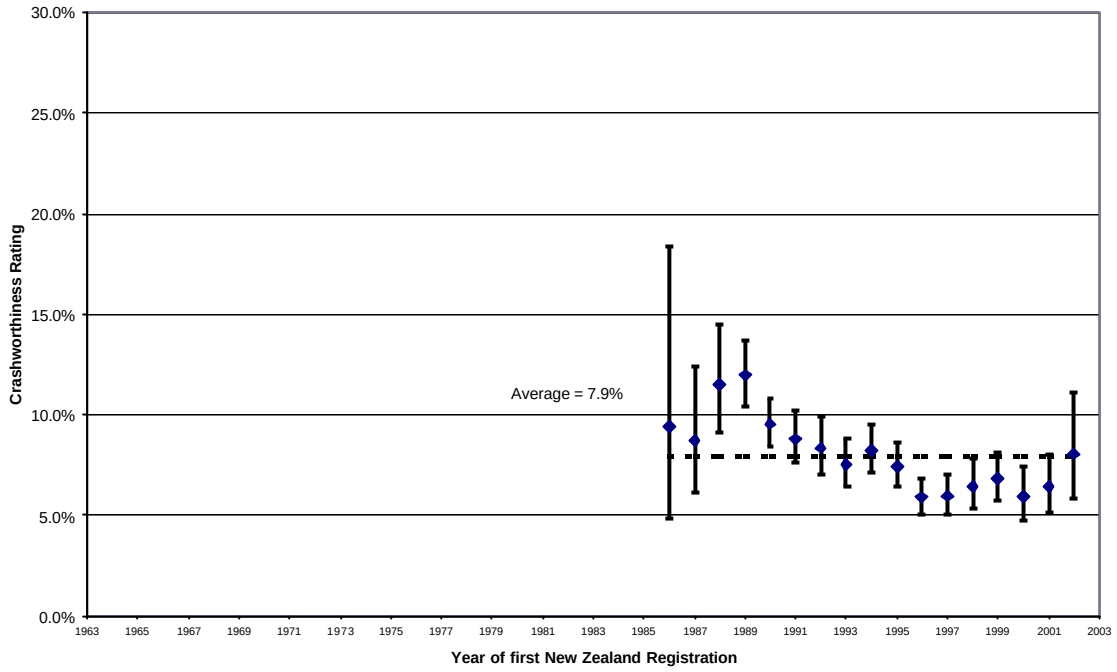
crash reduced by around 50% for the fleet as a whole. During this period vehicle safety in New Zealand was affected by several competing effects: a general increase in both active and passive safety features in vehicles; increasing proportions of used imported vehicles entering the New Zealand fleet; and increases in the regulation of vehicle safety standards by the New Zealand Government. Both the level of absolute crashworthiness and the trends on a year of manufacture basis were similar for used imports and for vehicles sold new in New Zealand.

Figure E1: *Crashworthiness by year of manufacture (with 95% confidence limits): Both new and imported used vehicles*



Estimates of crashworthiness trends in the vehicle fleet by year of first registration in New Zealand from 1978 to 1998 were also obtained. The data for used imports are shown in Figure E2 along with 95% confidence limits. They showed a high crashworthiness rating (indicating poor occupant protection performance) of newly registered vehicles in the early 1990's, the years when used imports suddenly began to penetrate the market. This was followed by statistically significant improvements in crashworthiness over the later years of that decade. Absolute levels of crashworthiness and improvements by year of first registration paralleled those seen in the analysis by year of manufacture but occurred some 6 years later, a lag equivalent to the average age of the used imported vehicles over the study period.

Figure E2: *Crashworthiness by year of first registration in New Zealand (with 95% confidence limits): Used Imports*



These results suggest that on a comparable year of manufacture basis used imported vehicles in New Zealand offer similar levels of occupant protection to those sold new. However, because the average age of used imported vehicles entering New Zealand is around 6 years, the crashworthiness benefits estimated for new vehicles are not reflected in the New Zealand used import vehicle fleet until 6 years later than was found for the NZ-new vehicles. As a result, the used import program has led to poorer overall crashworthiness of the New Zealand vehicle fleet than there would have been if all new registrations in a year were of new vehicles. The size of the deficit in crashworthiness performance increases with the proportion of used import sales. This, however, must be considered against the benefits of the used import program in apparently reducing the number of motorcycles on the road and consequently the number of motorcycle crashes. Further research is recommended to investigate fully the effects of the used import program on overall injury outcomes in New Zealand

The results and conclusions of this study are based on a number of assumptions and a number of qualifications should be noted.

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TRENDS IN VEHICLE CRASHWORTHINESS OF THE NEW ZEALAND VEHICLE FLEET BY YEAR OF MANUFACTURE: 1964 TO 2002

1. BACKGROUND AND AIMS

1.1 Crashworthiness Ratings

For over a decade, the Monash University Accident Research Centre (MUARC) has been involved in a program of research examining issues relating to vehicle safety in Australia through the analysis of mass crash data. A principal focus of the research has been to rate the relative performance of different vehicle models in preventing injury to their occupants in the event of a crash, commonly known as the crashworthiness of the vehicle. The crashworthiness ratings developed as part of the MUARC research rate the relative safety of vehicles by examining injury outcomes to drivers in real crashes. More specifically, the defined crashworthiness rating of a vehicle is a measure of the risk of death or serious injury to a driver of that vehicle when it is involved in a crash. This risk is estimated from large numbers of records of injury to drivers of that vehicle type involved in real crashes on the road.

In 1994, MUARC produced vehicle crashworthiness ratings based on crash data from Victoria and New South Wales during 1987-92 (Cameron et al, 1994a, b). These ratings updated an earlier MUARC set produced by Cameron et al (1992b). Crashworthiness was measured in two components:

1. Probability of injury for drivers involved in tow-away crashes (injury risk)
2. Probability of serious injury (death or hospital admission) for injured drivers (injury severity).

Multiplying these two probabilities together formed the crashworthiness rating. This is a measure of the probability of serious injury for drivers involved in crashes. Measuring crashworthiness in two components reflecting risk and severity of injury was first developed by Folksam Insurance, which publishes the well-known Swedish ratings (Gustafsson et al 1989).

The results of these ratings are summarised in Cameron et al (1994a) with a full technical description of the analysis methods appearing in Cameron et al (1994b). These ratings use an analysis method that was developed to maximise the reliability and sensitivity of the results from the available data. In addition to the speed zone and driver sex, the method of analysis adjusts for the effects of driver age and the number of vehicles involved, producing results with all those factors taken into account. Subsequent to the ratings of Cameron et al (1994a,b), regular updated sets of crashworthiness ratings have been produced incorporating some enhancements to the methods of statistical analysis and progressively adding police reported crash data from Queensland, Western Australia and most recently, New Zealand. Addition of the New Zealand data in the most recent update resulted from an extensive comparison of the compatibility of vehicles in the Australian and New Zealand fleets as well as a rigorous assessment of the suitability of New Zealand crash data for ratings estimation. Through this process, MUARC has gained an extensive knowledge of the content and limitations of the New Zealand vehicle crash and registration databases.

1.2 Crashworthiness by Year of Vehicle Manufacture

Another focus of the vehicle crashworthiness ratings study in Australia has been to track historical improvements in the average crashworthiness of the vehicle fleet by year of manufacture since 1964. In 1994, the Royal Automobile Club of Victoria (RACV) commissioned a study to investigate the effects of the year of manufacture of vehicles (vehicle year) on their road safety (Cameron et al 1994c). The project focused on investigating the relationship between crashworthiness and vehicle year of manufacture for the years 1964 to 1992 and its aim was, to the extent possible, to measure the crashworthiness of vehicles of different years of manufacture. The method employed was designed to eliminate the influence of other key factors affecting the risk of injury that might also be associated with vehicle year (e.g. driver age and sex, use on high speed roads, etc.).

The original study of Cameron et al (1994c) showed that the crashworthiness of passenger vehicles in Australia has improved over the years of manufacture 1964 to 1992 with rapid improvement over the years from about 1970 to 1979. Drivers of vehicles manufactured during 1970 to 1979 could be expected to have benefited from the implementation of a number of Australian Design Rules (ADRs) for motor vehicle safety which previous research had shown to be effective in providing occupant protection. The study has been updated with each vehicle crashworthiness ratings update. The most recent analysis covered Australian vehicles with years of manufacture from 1964 to 2002 (Newstead et al, 2004).

Newstead and Cameron (2001) extended the analysis of trends in vehicle crashworthiness by year of manufacture to examine trends within specific vehicle market groups. This analysis was most recently updated for vehicles manufactured over the years 1982-2002 (Newstead et al, 2004).

1.3 Project Aims

Although New Zealand data were combined with data from Australian states in producing the Used Car Safety Ratings (Newstead et al 2004), the information from New Zealand was not included in the estimates of crashworthiness by year of manufacture. This was because trends in crashworthiness by year of vehicle manufacture reflect the composition of a particular vehicle fleet in terms of the makes and models of vehicles in the fleet as well as the regulatory framework for vehicle safety in the country being examined.

The New Zealand and Australian vehicle fleets differ significantly in their mix of vehicle makes and models as well as the standards they were manufactured to meet. This is partly a result of the program of importing used vehicles into New Zealand (mainly from Japan) which began to have effect in 1987 when the percentage of used imports in new registrations in New Zealand rose from about 5% to about 13%. The levels of used imports rose again to about 50% over the next three years and at present about two-thirds of the newly registered light vehicles are used imports. Since most newly registered vehicles in Australia are new, estimation of combined trends for the two countries by year of manufacture would not be particularly meaningful. There is also the problem that innovations and new safety standards potentially flow more slowly into a fleet such as that in New Zealand which allows the import of large numbers of second-hand (used) vehicles from other countries.

The regulatory framework governing vehicle safety in New Zealand is also quite different to that in place in Australia. Australia has a very active vehicle manufacturing industry and requires that all vehicles must be manufactured in compliance with the Australian Design Rules (ADRs), so the quality is controlled at manufacture. By contrast New Zealand imports all its light vehicles and their quality is controlled at import. The various Land Transport Rules require that vehicles must have been manufactured in accordance with approved standards but they also provide a choice of equivalent standards, not just the ADRs, because the vehicles are sourced from other markets. Although both countries mandate the same standards, the timing of their implementation is quite different, which would be expected to lead to differences in crashworthiness by year of vehicle manufacture. For example, compliance with a frontal impact standard for occupant protection was implemented for cars manufactured after 1996 in Australia. A similar rule was only mandated for cars entering New Zealand after April 2002.

The aim of this project was to investigate the relationship between vehicle crashworthiness and vehicle year of manufacture for the years 1964 to 2002 for the New Zealand passenger vehicle fleet as a whole. Analysis aimed to estimate trends in crashworthiness separately for vehicles sold new in New Zealand and for imported used vehicles. To assess the safety of the used imports brought into New Zealand in any particular year, the project also aimed to assess the trend in safety of the New Zealand used imports by examining crashworthiness by year of first registration in New Zealand.

2. DATA

Vehicles manufactured over the period 1964-2002 and crashing in New Zealand during the years 1991-2002 were used in the analysis. The methods of selecting appropriate cases for analysis of trends in vehicle crashworthiness by year of manufacture will be detailed here.

The New Zealand data used in this project was as used in Newstead et al 2004 with the addition of pre-1982 vehicles. Two sources of data from New Zealand were used The first was a crash file showing the registration, vehicle, driver and various crash characteristics for all police-reported crashes in New Zealand for the years 1991 to 2002. The second was registration data giving details of all crash-involved vehicles on the NZ register in each year from 1991 to 2002. Extracts from both data sources used in the estimation of vehicle safety ratings are described below.

2.1 Crash Data

NZ has an established database of police-reported crashes over many years. Amongst many other things, the data are used to produce the annual publication "Motor Accidents in New Zealand" summarising injury crashes in NZ (LTSA, 1998, for example). The crash data are stored in the Crash Analysis System (CAS) database managed by Land Transport New Zealand and covers both injury and non-injury crashes. Whilst non-injury crashes are available from CAS, the reporting coverage of non-injury crashes in NZ is not as clear. The problem is that it is not mandatory for a non-injury crash to be reported to the Police so the number, nature and degree of vehicle damage, if any, are not known. Because of this, and because of problems with vehicle model identification documented by Voyce (2000), only injury crash data from New Zealand were available for estimating vehicle safety ratings.

To facilitate the use of NZ crash data in computing vehicle crashworthiness ratings, there were a number of key variables in the crash data supplied. These variables were required to represent the effects of non-vehicle factors on injury outcome in order to be able to estimate crashworthiness ratings that represented only the vehicle influences on injury outcome. The key variables available in the data were as follows.

- Year of crash (1991, 1992,…, 2002)
- Speed limit at crash location (<80km/h, >=80km/h)
- Number of vehicles involved (1, more than 1)
- Level of urbanisation of crash location (urban, rural)
- Driver age (<=25 years, 26-59 years, >=60 years)
- Driver gender (male, female)
- Injury level of driver (killed, hospitalised, other injury, not injured)

Data in CAS are stored as a relational database, comprising a series of linked tables with each covering a different theme related to a crash. Land Transport NZ supplied details of the data fields available in the CAS system through a data dictionary of the database. Data from three tables, crash, person and vehicle, covered all the required data filed listed above. Linking data in the tables together was achieved using the crash identification number (crash_id), traffic unit identifier (ltsa_role) and person identifier (pers_id) fields.

Complete extracts of each data table for the years 1991 to 2002, without personal identifier information, were supplied for analysis. From these, it was possible to select the required data for analysis from the supplied tables. In total, 123,707 crashes involving 211,408 traffic units were recorded in the crash file during this period. Not every unit in the file represented a vehicle that could be rated. Units also included motorcycles, bicycles, pedestrians and heavy vehicles.

2.2 Registration Data

Information from the NZ motor vehicle register on vehicle make, model and year of manufacture was required to enhance the crash data for estimation of vehicle crashworthiness ratings. The New Zealand Transport Registry Centre (TRC) held the required data (see TRC, 2000, for an overview on registration data and the New Zealand vehicle fleet). Data was requested covering all vehicles appearing in the 1991-2002 New Zealand crash data with current or historical (archived) registration records. Registration records for vehicles appearing in the crash data were selected based on registration plate number, assuming the plate number had been recorded accurately by the police in the crash data.

Variables required from the registration database were selected based on information from the Pre-registration Procedures Manual supplied by TRC with reference to information required for accurate vehicle model decoding. Variables requested were as follows (with reference to the current version of the Pre-Registration Procedures Manual where available).

- Vehicle registration number (plate number)
- Vehicle Identification Number (VIN) (4-A-1)
- Vehicle Type (4-A-3)

- Registration Indicator (4-A-5)
- Date of Registration
- Date of First NZ Registration (4-A-6)
- Country of Previous Registration (4-A-7)
- Make (4-A-8)
- Model (4-A-8)
- Sub-model Name (4-A-8)
- Industry Model Code (4-A-8)
- Year of manufacture (4-A-8)
- Body Type (4-A-9)
- Country of Origin (4-A-10)
- Assembly Type (4-A-10)
- CC Rating (4-A-10)

Of the variables requested, a number were vital for clustering vehicles appearing in the New Zealand crash data for analysis by year of manufacture. These were vehicle type, year of manufacture, registration number, the date of registration, the date of first New Zealand registration and whether the vehicle was sold new in New Zealand, was a used import or re-registered. For some years there was some difference in the recording of year of manufacture and date of first registration anywhere but the errors are reported to be small.

One difficulty in retrieving vehicle registration information details for crashed vehicles based on only the registration plate number arose for registration plates that had been used on more than one vehicle model over time. It was not possible for the TRC to find the registration record that was current for a plate number just before the time the vehicle crashed. Instead, all records for the plate number of a crashed vehicle were retrieved from the registration system and archive. Where multiple records for a single plate number were provided, the most appropriate match based on the date of the crash, the date of registration and the date of first registration of the vehicle in New Zealand needed to be established. The process for doing so is described below. In some cases a registration record could not be found for a crashed vehicle. This was most likely because either the registration plate details had been recorded incorrectly in the crash data or the vehicle was not registered.

For the 211,408 units involved in crashes in the data supplied for 1991 to 2002, 186,872 registration records were extracted by the TRC from the New Zealand vehicle register. The total number of registration records is less than the number of units because registration records for some vehicles could not be identified along with some units being pedestrians and bicycles that are not registered.

2.3 Merging the Crash and Registration Data

The New Zealand registration and crash files were matched to provide full vehicle and crash information for each crash-involved unit. This required the vehicle details obtained from the registration files to be matched with the crash files based on the registration number. This process raises some unique difficulties. First, in some instances the same vehicle may have crashed more than once between 1991 and 2002 causing multiple records for the same vehicle to appear in the registration file. Selecting those cases where the date of registration, the date of first NZ registration,

vehicle make, model and registration details were identical identified these cases. Multiple entries were then deleted from the registration file.

Second, it was possible that the same registration number may be associated with more than one vehicle over time and with multiple registrations of the same vehicle due to re-registration. If any of these vehicles were involved in a crash during the relevant period, all vehicles on the NZ register between 1991 and 2002 with the relevant registration numbers appeared as unique entries in the registration data file. In cases of multiple entries with the same registration number, it was necessary to identify which of the vehicles on the registration file best matched the vehicle involved in the crash as shown in the crash file. Registration details were matched to crashes by selecting the most recently registered vehicle prior to the accident date using both the date of the first New Zealand registration and the registration date of the vehicle.

Finally, in cases where the registration number was unknown or incomplete the crash and registration data could not be matched. At the completion of the matching process, 187,326 entries remained in the merged file containing the relevant variables from both the crash and registration files. This process of matching used here is an enhancement of that described in Newstead et al (2003) for matching New Zealand crash and registration data.

Only vehicles manufactured after 1964 and only entries coded as cars, station wagons, vans or utilities were relevant to the analysis. This left 143,723 light passenger vehicles for analysis from which the drivers' injury outcomes were used for estimation of the crashworthiness measure. Records on the uninjured drivers in the New Zealand injury crash data are incomplete because non-injury crashes in New Zealand, and hence uninjured driver details from these crashes, are not required to be reported. This meant driver injury risk could not be directly estimated from the available data. To overcome this limitation, a new method of calculating injury risk from incomplete data was utilised. This is described in Section 3.1 and involved matching two-vehicle crashes and comparing the injury outcome of the drivers in the two vehicles. Established methods were used for measuring the injury severity of injured drivers recorded in the data.

3. ANALYSIS METHODS

3.1 The Crashworthiness Measure

The crashworthiness rating (C) is a measure of the risk of serious injury to a driver of a car when it is involved in a crash. Following the method traditionally used by MUARC, it is defined to be the product of two probabilities (Cameron et al, 1992):

i) the probability that a driver involved in a crash is injured (injury risk), denoted by R;

and

ii) the probability that an injured driver is hospitalised or killed (injury severity), denoted by S.

That is

$$C = R \times S.$$

Folksam Insurance, who publish the well-known Swedish ratings, first measured crashworthiness in this way (Gustafsson et al, 1989). This method has previously been used to produce the Australian and New Zealand vehicle fleet crashworthiness ratings (Newstead et al, 2004).

Because non-injury crashes are not reliably reported in the New Zealand crash data, injury risk cannot be measured directly from the data (as a simple ratio of injured drivers over total involved drivers) as it is in calculating the vehicle specific ratings of Newstead et al (2004). The alternative of calculating the proportion of injured drivers amongst those involved in injury crashes results in a biased estimate of injury risk. To overcome these problems, an alternative measure of injury risk has been used here which is based on the paired comparison approach but leads to unbiased estimates. A description of the derivation of the injury risk estimator follows. It is further described in Cameron et al (2001) where it is also compared to more traditional estimators of injury risk that are also derived using the paired comparison approach but which have the problem of being biased.

Consider N observed two-car crashes involving vehicle model (or year of manufacture) k. Let p_{1k} be the average injury probability to the driver of the focus vehicle model (or year of manufacture) k, and p_{2k} be the average injury probability to the drivers of all vehicles colliding with vehicle model (or year of manufacture) k. Categorising the N observed crashes into a 2x2 table defined by injury or non injury to the focus and other vehicle drivers, the following table of expected crash frequencies arises, assuming p_{1k} and p_{2k} to be independent.

Table 1: *Expected number of two-car crashes between vehicle model (or year of manufacture) k and other vehicles*

Drivers of vehicle model or year of manufacture *k*	**Drivers of other vehicles**		
	INJURED	NOT INJURED	
INJURED	$N\,p_{1k}\,p_{2k}$	$N\,p_{1k}\,(1-p_{2k})$	$N\,p_{1k}$
NOT INJURED	$N(1-p_{1k})p_{2k}$	$N(1-p_{1k})(1-p_{2k})$	$N\,(1-p_{1k})$
	$N\,p_{2k}$	$N\,(1-p_{2k})$	N

The observed categorised crash frequencies corresponding to the expected values under the conceptual framework in Table 1 for vehicle model or year of manufacture k are shown in Table 2.

Table 2: *Observed number of two-car crashes between vehicle model (or year of manufacture) k and other vehicles*

Drivers of vehicle model *k*	**Drivers of other vehicles**		
	INJURED	NOT INJURED	
INJURED	n_{iik}	n_{ink}	$n_{iik}+n_{ink}$
NOT INJURED	n_{nik}	n_{nnk}	$n_{nik}+n_{nnk}$
	$n_{iik}+n_{nik}$	$n_{ink}+n_{nnk}$	N

The traditional MUARC measure of injury risk can be derived from the margin of Table 2 and is given by the following.

$$R_{Mk} = \frac{n_{iik} + n_{ink}}{N}$$

The corresponding expected value is given by

$$E(R_{Mk}) = p_{1k}$$

R_{Nk} is an unbiased estimator of p_{1k} and, as is ideal, is not confounded with the aggressivity parameter for vehicle model k, p_{2k} which can be estimated independently. The empirical independence of p_{1k} and p_{2k} is demonstrated in Newstead et al (2004).

For data systems such as New Zealand that do not report all non-injury crashes, n_{nnk} and N will be unknown in Table 2. For this reason, the MUARC estimator of injury risk cannot be calculated, hence the reason for using the alternative estimator.

The alternative measure of driver injury risk in vehicle model or year of manufacture k is defined as follows:

$$R_{Nk} = \frac{n_{iik}}{n_{iik} + n_{nik}}$$

The corresponding expected value is given by

$$E(R_{Nk}) = p_{1k}$$

As evident, R_{Nk} is also an unbiased estimator of p_{1k} and as such has the desired property of not being confounded with the aggressivity parameter for vehicle model k, p_{2k}. Conceptually, the new injury risk estimator measures the risk of injury in vehicle model k given the driver of the vehicle colliding with vehicle model k is injured.

Although not used in this study, the corresponding estimator of vehicle aggressivity injury risk of vehicle model k is given by

$$A_{Nk} = \frac{n_{iik}}{n_{iik} + n_{ink}}$$

Its expected value given by

$$E(A_{Nk}) = p_{2k}$$

This is an unbiased estimator of p_{2k}, the aggressivity injury risk of vehicle model k.

The injury risk measure used here has been combined with an injury severity measure identical to that used in the MUARC crashworthiness rating systems. This produces a crashworthiness measure identical in construction and concept to the MUARC measure but based on injury crashes only. The

only key difference between the MUARC measure of injury risk and the new measure used here is the scaling of the estimates. The new measure of injury risk is conditional on the driver of the other vehicle in a two-vehicle crash being injured and hence the average injury risk will be higher than when all crashes are considered, as is the case for the MUARC method. Consequently, the absolute estimates of crashworthiness by year of manufacture estimated in this study for New Zealand are not comparable with those estimated for Australia by Newstead et al (2004). However, the relative trends in crashworthiness by year of vehicle manufacture estimated for each country are consistent and comparable.

3.2 Adjusting for Non-Vehicle Factors: The Logistic Model

The crashworthiness risk and severity measures are unbiased estimators of absolute injury probabilities. Furthermore, the unit record data on driver injury from which they are estimated are binary responses indicating injury outcome. For the injury risk data, each case is classified as injured or not injured, using only those cases for which the driver of the colliding vehicle is injured. For the injury severity data, each driver is classified as either killed or seriously injured or suffering only minor injury. As such, both the risk and severity measures are amenable to estimation via logistic regression techniques. As well as estimating injury risk or severity as a function of vehicle model or year of manufacture, logistic regression allow simultaneous adjustment of concomitant non-vehicle factors affecting either injury risk or severity, such as driver age and sex.

The logistic model of a probability, P, is of the form:

$$\log it(P) = \ln\left(\frac{P}{1-P}\right) = b_o + b_1 X_1 + \ldots + b_k X_k = f(X).$$

That is, the log of the odds ratio is expressed as a linear function of k associated variables or their interactions ($X_i, i = 1,\ldots,k$). Estimates of the parameter coefficients of the logit function, i.e. the $\hat{\beta}_i$ can be obtained by maximum likelihood estimation (Hosmer & Lemeshow, 1989).

Whilst it is possible to calculate the variance of $\hat{f}(X)$, in the context of crashworthiness ratings we are only interested in the component of variance due to one factor in $\hat{f}(X)$, with the variance due to the other factors in the model being of no interest. In practice, the component of variance due to the factor representing the vehicle year of manufacture is of interest, whilst the variance due to the remaining factors such as driver age and sex is common to all vehicle years of manufacture and hence of no interest.

To isolate the component of variance in the logistic model due to only one factor, say X_i, the remaining factors were fixed at a predetermined level (their mean value). The variance of $\hat{f}(X)$, considering all factors apart from X_i to be fixed, is then given by

$$Var\left(\hat{f}(X_i)\right) = X_i^2 Var\left(\hat{b}_i\right)$$

In the logistic models of injury risk or injury severity, X_i was a [0, 1] indicator function of a particular year of manufacture. Hence the variance function given above equalled the variance of the coefficient $\hat{b}_i$.

A 95% confidence interval for the logit function with respect to component X_i is given by

$$\hat{f}(X) \pm 1.96\sqrt{Var\left(\hat{f}(X_i)\right)} .$$

Point estimates and confidence limits in the logistic space were transformed into probability estimates using the inverse logistic transform given by

$$\hat{P} = \frac{e^{\hat{f}(X)}}{1 + e^{\hat{f}(X)}} .$$

3.2.1 Logistic Models for Each Component

Obtaining the Covariate Models

The purpose of using logistic regression models was to compensate for the effects of possible factors, other than those related to the vehicle, that might have influenced the crash outcomes in terms of driver injury risk or severity. This was particularly important when the parameter of interest in the logistic regression, in this case the year of manufacture, was confounded with the non-vehicle factors. Appendix 1 shows the distribution of the non-vehicle factors driver age and sex and speed zone of crash by year of manufacture. Clearly, each of these non-vehicle factors varies in its distribution by year of manufacture, demonstrating that the estimates of injury risk or severity would be confounded with these factors were an adjustment process not undertaken.

A stepwise procedure was used to identify which factors of those available in the data had an important influence on injury outcome. This was done without considering the year of manufacture in the model, as the aim was to determine which other factors were most likely to have had an influence across a broad spectrum of crashes. Furthermore, it was also not considered appropriate to interact vehicle year of manufacture with other factors in the logistic model. This is because it was not the aim of the analysis to investigate variation in relative vehicle crashworthiness by year of manufacture by the crash circumstance and occupant characteristics. Rather, the aim was to estimate the average crashworthiness by year of manufacture across all crash and occupant characteristics.

Logistic models were obtained separately for crashworthiness injury risk and crashworthiness injury severity because it was likely that the various factors would have different levels of influence on these two probabilities. The factors considered during this stage of the analysis for both crashworthiness injury risk and crashworthiness injury severity were as follows.

- **sex:** driver sex (male, female)
- **age:** driver age (≤25 years; 26-59 years; ≥60 years)
- **speedzone:** speed limit at the crash location (<80 km/h; ≥80 km/h)
- **year:** year of crash (1987, 1988, … ,2002)

For crashworthiness injury severity the following factor was also considered.

- **nveh:** the number of vehicles involved (one vehicle; >1 vehicle)

These variables were chosen for consideration because they were part of the New Zealand database and are variables that have been shown to have significant relationship to injury outcome in the Australian and New Zealand combined vehicle safety ratings. Inclusion of the year of the crash in the logistic model was necessary to account for different long-term trends.

All data was analysed using the Logistic Regression procedure (PROC LOGISTIC) of the SAS statistical package (SAS, 1989). Estimates of the coefficients of the logit function, $\hat{\beta}_i, i = 1, \ldots, k$, together with their associated standard errors, were obtained by maximum likelihood estimation. In the modelling process, design variables for the various factors were chosen in such a way that the estimated coefficients represented deviations of each of the variable levels from the mean. Each factor in the model, including year of crash, was treated as categorical to allow maximum flexibility in the relationship between each and the outcome measure.

In separate models for both crashworthiness injury risk and crashworthiness injury severity, a stepwise procedure was used to identify which factors and their interactions, other than year of manufacture, made a significant contribution to these probabilities. All possible first and higher order interactions were considered between all factors in the model. To enhance computational efficiency, a hierarchical structure was imposed so that interaction between two variables was included in the model only when the corresponding main effects were also included. The resultant logistic regression models were referred to as the "covariate" models.

Assessing Year of Manufacture Differences

Crashworthiness injury risk and crashworthiness injury severity for individual years of vehicle manufacture were estimated after adding a variable representing year of manufacture to the terms identified as being statistically significant in each respective logistic "covariate" model and re-estimating all parameters. The model was re-estimated in a single step process. Coefficients for individual years of manufacture were computed to represent deviations of that year from the average. The year of manufacture was treated as categorical in the model in order to place no constraint on the functional form of the relationship between injury outcome and year of manufacture.

While it was important to ensure that the logistic model adequately described the data and did not yield individual year coefficients that were imprecise or unstable it was important to examine earlier years of manufacture with limited data for any trends. For this reason, individual years with small frequencies were monitored and excluded only from the analysis if individual year coefficients were unstable. Imprecise individual year coefficients were included with 95% confidence intervals as an indication of the individual year estimates precision. Years may have been excluded if there were either:

i) less than 100 involved drivers; or
ii) less than 20 injured drivers.

The regression analyses were generally performed on 39 individual years of manufacture. A list of all years considered, with those with sufficient data for analysis indicated, is given in each of Appendices 2, 4, 6 and 8. The choice of the design for the logistic model allowed the injury risk and injury severity estimates for each individual year to be compared with the overall (average) rating for all years.

For each year of manufacture, a 95% confidence interval for the logit functions of injury risk and injury severity was obtained after first adjusting for the average value of risk or severity in the data and then allowing for the deviation from average for that particular year represented by the parameter estimate. The average value of the crashworthiness injury risk or crashworthiness injury severity was obtained directly from the outcome variable of interest averaging across all cases in the analysis. The 95% confidence limit was calculated using the variance of the parameter estimate for each year of manufacture.

Estimates of injury risk and injury severity probabilities and their corresponding 95% confidence limits were obtained by de-transforming the logit functions in the standard way. The precision of the estimates of injury risk and injury severity is measured by the width of these 95% confidence intervals along with the coefficient of variation measure which is the ratio of confidence limit width to point estimate value.

3.3 Combining the Injury Risk and Injury Severity Components

The final combined ratings of vehicle crashworthiness are given by:

Crashworthiness Rating = Injury risk x Injury severity.

For a given year of manufacture, j, the crashworthiness rating, C_j, was therefore calculated as:

$$C_j = R_j \times S_j$$

where

R_j denotes the injury risk for year of manufacture j, and
S_j denotes the injury severity for year of manufacture j.

Noting the form of the logistic inverse transformation in section 4.1 above, we have

$$R_j = \frac{e^{a_j}}{1+e^{a_j}}, \qquad S_j = \frac{e^{b_j}}{1+e^{b_j}}$$

where a_j and b_j are the values of the logistic regression function $\hat{f}(X)$ for injury risk and injury severity respectively for year of manufacture j.

Taking the natural log of the crashworthiness rating and using asymptotic statistical theory, the asymptotic variance of the log of the crashworthiness rating is

$$Var(\log_e C_j) \approx \frac{Var(a_j)}{(1+e^{a_j})^2} + \frac{Var(b_j)}{(1+e^{b_j})^2}$$

where the variances of a_j and b_j are as given in section 3.1 and the estimates of a_j and b_j are considered independent.

The 95% confidence interval for the natural log of the crashworthiness rating is then

$$\log_e(C_j) \pm 1.96 \cdot \sqrt{Var\left(\log_e(C_j)\right)}.$$

The 95% confidence limit for the crashworthiness rating is obtained by taking the exponent of the confidence limit of the logged crashworthiness rating shown above.

Because each of the two estimated crashworthiness components have been adjusted for the effect of other factors by logistic regression prior to their incorporation into the combined ratings, the resultant crashworthiness rating is also intrinsically adjusted for the influence of these factors. It should be noted that the confidence interval for the combined rate reflects the variability in the year of manufacture or first year of registration only and not the variability in the other factors included in the logistic models.

4. RESULTS

4.1 Crashworthiness by Year of Manufacture

4.1.1 Injury Risk

Injury risk was estimated from the data on 63,010 drivers involved in a two-vehicle collision during 1991 to 2002 where the other driver was injured. This data set is referred to as the "involved drivers". Because of missing values of some of the factors to be included in the logistic regression, and the exclusion of pre-1964 vehicles and unknown years, analysis was performed on data relating to 33,849 involved drivers, 14,799 of whom were injured. For vehicles sold new in New Zealand, analysis was performed on data relating to 19,066 involved drivers, 8,264 of who were injured. For used imported vehicles, analysis was performed on data relating to 8,814 involved drivers, 3,678 of who were injured. It should be noted that the numbers of new and used imported vehicles analysed does not add up to those in the overall analysis because of missing information on the import status of some vehicles and because of the exclusion of re-registered vehicles from the disaggregated analyses. This is also the case for the injury severity analysis reported below.

The "covariate" model for injury risk for each category of vehicle (sold new in New Zealand, used imports and all vehicles combined) was determined from the variables described in Section 3.2.1. The following covariates and interactions were statistically significantly associated with injury risk and were included in the logistic regression models.

Vehicle class	Base effect terms	First order interactions	Second order interactions
Sold new in New Zealand	*Age*	*Sex*Speedzone*	
	Sex		
	Speedzone		
	Year (of crash)		
Used imports	*Age*		
	Sex		
	Speedzone		
	Year (of crash)		
All vehicles	*Age*	*Age*Sex*	*Age*Sex*Speedzone*
	Sex	*Age*Speedzone*	
	Speedzone	*Sex*Speedzone*	
	Year (of crash)	*Year*Speedzone*	

No other variable or interaction term significantly improved the fit of each of the logistic models.

The overall (average) injury risk for involved drivers in matched two-vehicle casualty crashes in New Zealand where the opposing driver was injured was 43.7%. In other words, the estimated probability that a driver involved in a two-vehicle crash in New Zealand was injured where the colliding vehicle driver was also injured was 43.7%. For drivers of vehicles sold new in New Zealand the overall (average) injury risk was 43.2% and for drivers of used imports the overall (average) injury risk was 41.7%. It should be noted that there was only sufficient data for used imported vehicles to estimate injury risk for the years of manufacture 1978 to 1998.

Appendix 3 gives the estimates of injury risk derived by logistic regression for each individual year of manufacture for all vehicles combined. Appendix 5 gives the corresponding estimates of injury risk for vehicles sold new in New Zealand whilst Appendix 7 gives the estimates of injury risk for used import vehicles. The variability in the injury risk estimates relative to the year of manufacture can be seen from the width of the corresponding 95% confidence intervals. Figures 1 to 3 give plots of injury risk by year of vehicle manufacture and associated 95% confidence limits for all vehicles, vehicles sold new in New Zealand and used imports respectively.

Figure 1: *Injury risk by year of manufacture (with 95% confidence limits): All Vehicles*

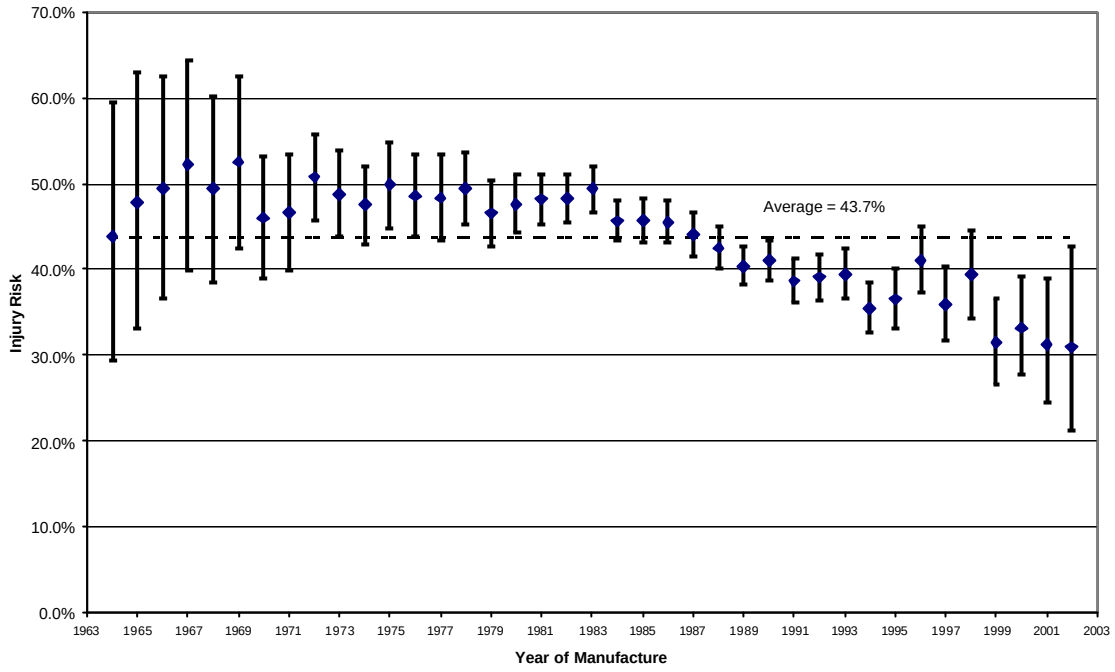


Figure 2: *Injury risk by year of manufacture (with 95% confidence limits): Vehicles sold new in New Zealand*

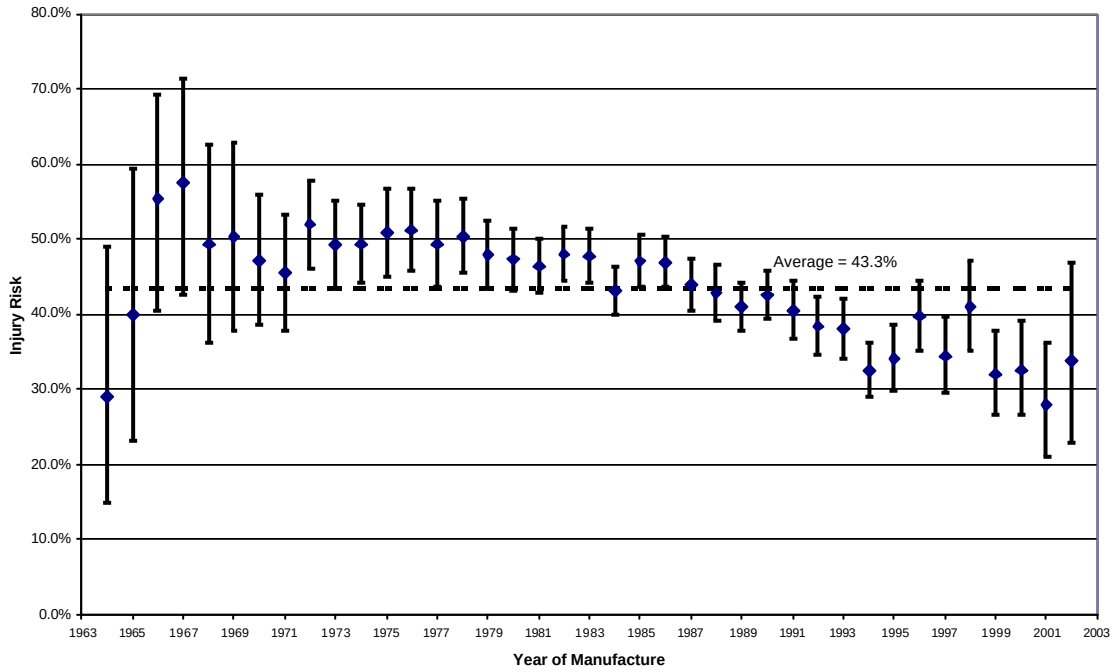
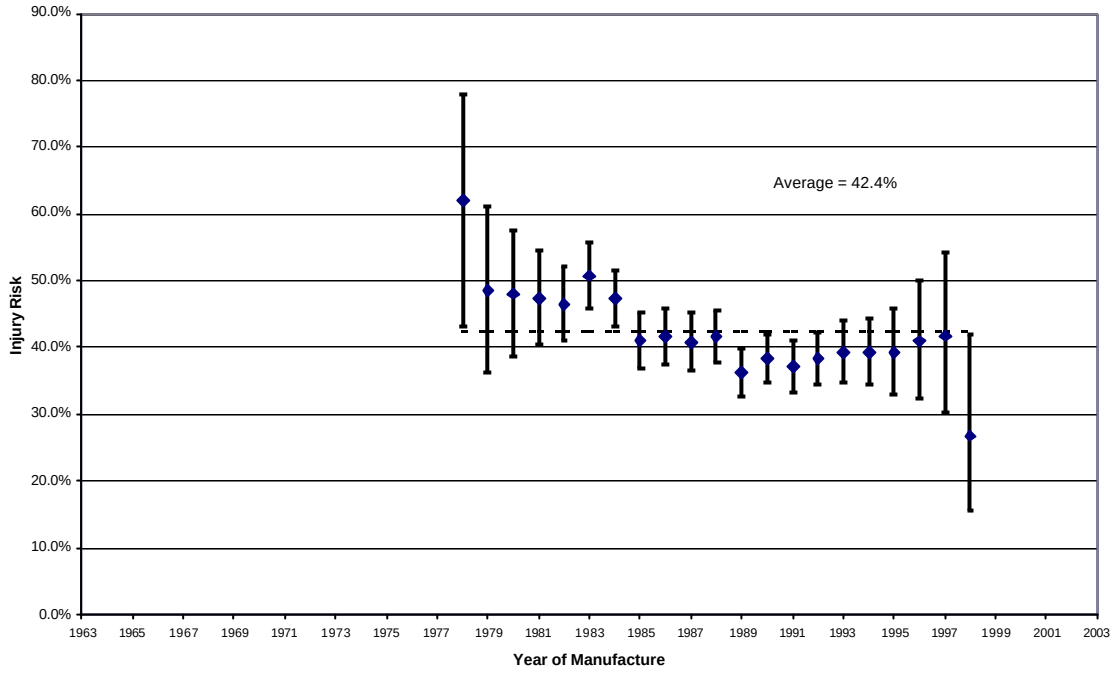


Figure 3: *Injury risk by year of manufacture (with 95% confidence limits): Used Imports*



4.1.2 Injury Severity

The data on "injured drivers" covered 143,723 drivers who were injured in crashes in New Zealand during 1991-2002 (as described in Section 2). Because of missing values of some of the associated crash factors and the exclusion of pre-1964 vehicles and unknown years, logistic regression was performed on data relating to 73,809 injured drivers 14,828 of who were severely injured (killed or admitted to hospital). For vehicles sold new in New Zealand, analysis was performed on data relating to 42,090 injured drivers, 8,368 of who were severely injured. For used import vehicles, analysis was performed on data relating to 9,269 injured drivers, 3,918 of who were severely injured.

Significant variables identified in the covariate model for each vehicle class are as follows.

Vehicle class	Base effect terms	First order interactions
Imported as new	*Age*	*Speedzone*Nveh*
	Sex	*Age*Sex*
	Nveh	*Age*Nveh*
	Speedzone	
	Year (of crash)	
Imported as used	*Age*	*Speedzone*Nveh*
	Sex	*Age*Sex*
	Speedzone	*Age*Nveh*
	Nveh	
	Year (of crash)	
All vehicles	*Age*	*Speedzone*Nveh*
	Sex	*Age*Sex*
	Nveh	*Age*Nveh*
	Speedzone	*Age*Speedzone*
	Year (of crash)	

No other variable or interaction term significantly improved the fit of each of the logistic model.

The overall (average) injury severity for injured drivers in all vehicles was 20.1%. In other words, the estimated probability that a driver injured in a crash was severely injured was 20.1%. For drivers of vehicles sold new in New Zealand the overall (average) injury risk was 19.9% and for drivers of vehicles imported used the overall (average) injury risk was 19.5%. As for injury risk, there was only sufficient data to estimate injury severity for the years of manufacture from 1978 to 1998. This also explains why the average injury severity for both used imports and vehicles sold new in New Zealand are less than the overall average.

Appendix 3 gives the estimates of injury severity derived by logistic regression for the individual years of manufacture for all vehicles. Appendix 5 and Appendix 7 give the corresponding estimates for vehicles sold new in New Zealand and for used imports respectively. The variability in the estimates of injury severity relative to year of manufacture can be seen from the width of the corresponding 95% confidence intervals. Figures 4 to 6 give plots of injury severity by year of vehicle manufacture and associated 95% confidence limits for all vehicles, vehicles sold new in New Zealand and used imports respectively.

Figure 4: *Injury severity by year of manufacture (with 95% confidence limits): All Vehicles*

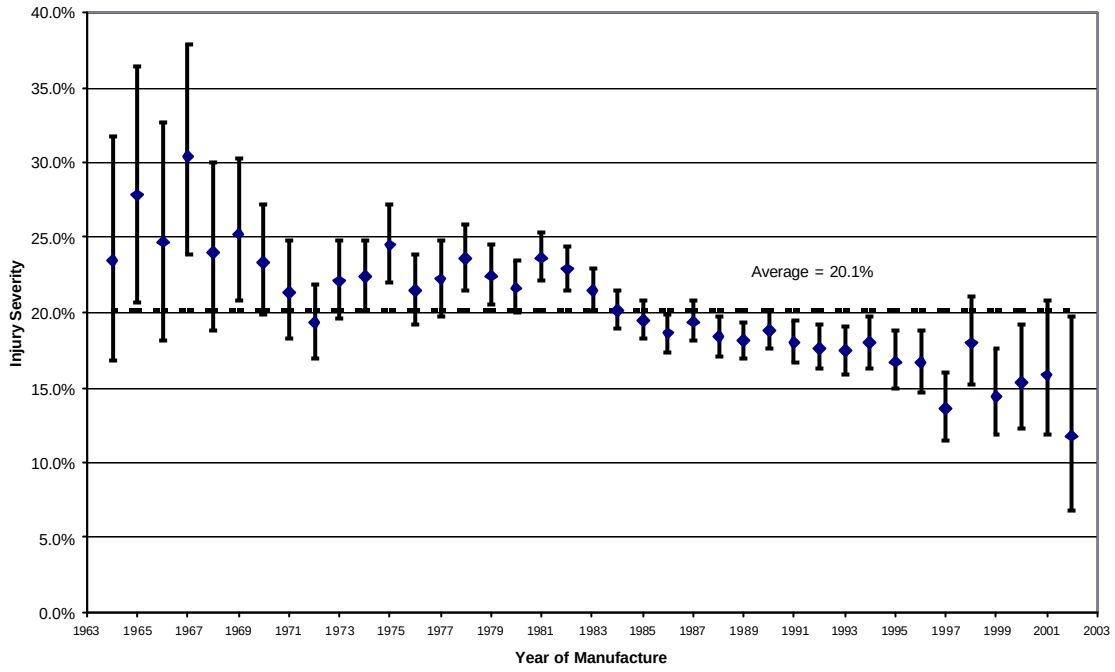


Figure 5: *Injury severity by year of manufacture (with 95% confidence limits): Vehicles sold new in New Zealand*

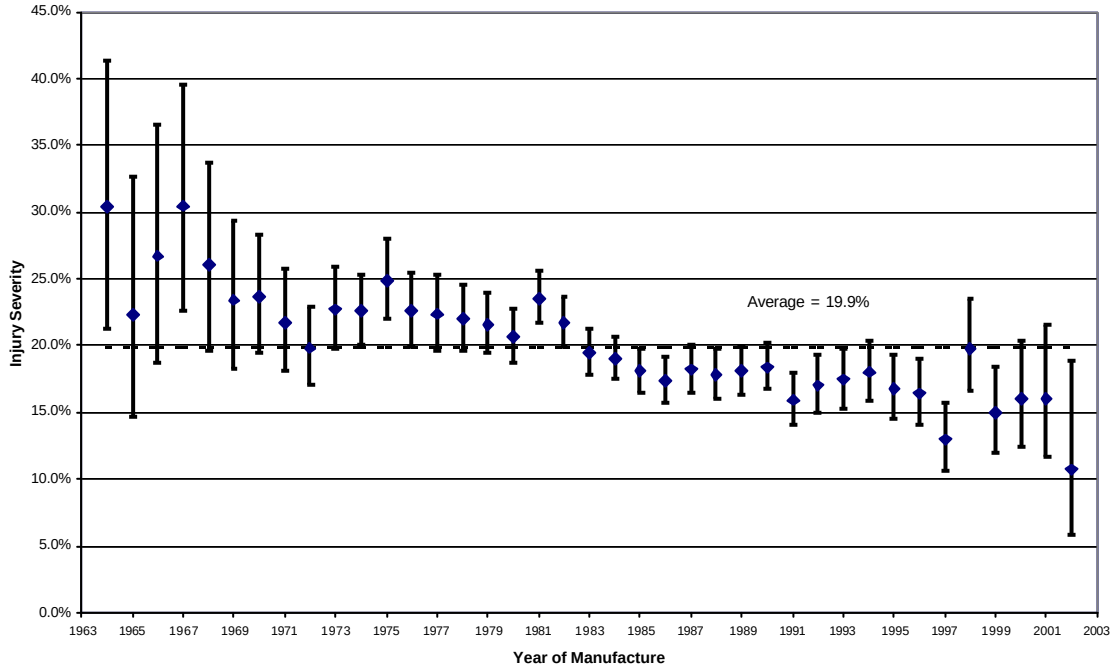
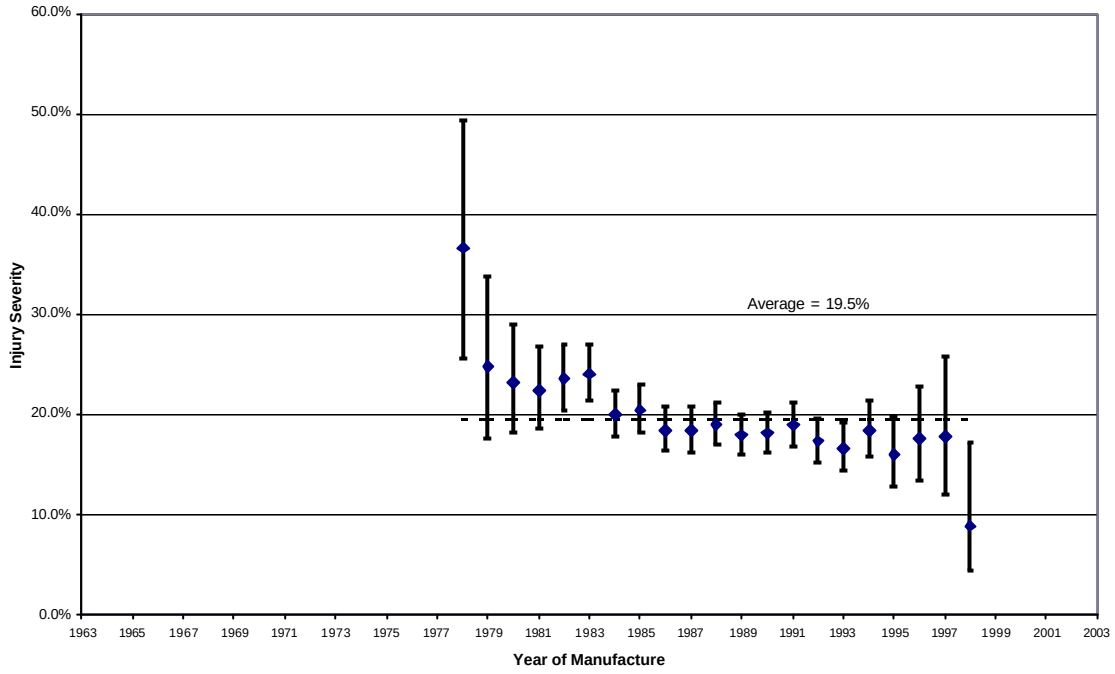


Figure 6: *Injury severity by year of manufacture (with 95% confidence limits): Used Imports*



4.1.3 Crashworthiness by Year of Manufacture

The crashworthiness estimates for each year of manufacture were obtained by multiplying the corresponding individual injury risk and injury severity estimates. Because each of the two components has been adjusted for the confounding factors, the resultant crashworthiness estimate is also intrinsically adjusted for their influence.

Appendices 3, 5 and 7 give the crashworthiness estimates and the associated 95% confidence intervals for each of the years of manufacture included in the analysis for all vehicles, for vehicles sold new in New Zealand and for used import vehicles respectively. Each estimate is expressed as a percentage, representing the number of drivers killed or admitted to hospital per 100 drivers involved in a crash.

The true risk of a driver being killed or admitted to hospital in a crash is only estimated by each figure, and as such each estimate has a level of uncertainty about it. This uncertainty is indicated by the confidence limits in Appendices 3, 5 and 7. There is 95% probability that the confidence interval will cover the true risk of serious injury (death or hospital admission) to the driver of a vehicle of the particular year of manufacture.

The crashworthiness estimates and their confidence limits are plotted for each year of manufacture for all vehicles (both new and used imports) in Figure 7. The relatively wide confidence intervals observed on the estimates of crashworthiness for years of manufacture 1964 to 1969 and 2002 are a reflection of the smaller numbers of crashes involving vehicles manufactured in these years appearing in the data. Figure 7 shows general and significant improvement in vehicle crashworthiness with increasing year of manufacture over the years considered. Specifically, little improvement can be seen in the years 1964 to 1983 followed by rapid improvement over the period 1984 to 1995 with

vehicles manufactured from 1988 being statistically significantly safer on average than those manufactured before 1983. With the exception of 1996 and 1998, there is visual evidence of a decreasing trend in the period after 1995. Examination of the corresponding risk and severity plots for all vehicles in Figure 1 and 4 respectively show the improvements in crashworthiness with year of manufacture observed in Figure 7 are due to improvements in both injury risk and injury severity by year of vehicle manufacture.

The crashworthiness estimates and their confidence limits are plotted for each year of manufacture for vehicles sold new in New Zealand in Figure 8. The relatively wide confidence intervals observed on the estimates of crashworthiness for years of manufacture 1964 to 1969 and 2002 are again a reflection of the smaller numbers of crashes involving vehicles manufactured in these years appearing in the data. As expected, trends in the early years are identical to the trend for all vehicles combined given the New Zealand used import program only grew dramatically from 1987 and the three years thereafter. Figure 8 shows that the general and significant improvement in vehicle crashworthiness with increasing year of manufacture over the years considered was similar for NZ-new vehicles to the improvement for all vehicles shown in Figure 7. Again, this improvement seems to stem from improvements in both injury risk and injury severity in later years of manufacture.

Figure 9 gives the crashworthiness estimates and their confidence limits for each year of manufacture for used imports. The relatively wide confidence intervals observed on the estimates of crashworthiness for years of manufacture 1978, 1979, 1997 and 1998 are again a reflection of the smaller numbers of crashes involving used import vehicles manufactured in these years. Trends in crashworthiness by year of manufacture for used import vehicles in Figure 9 do not appear as strong as those observed for vehicles sold new in New Zealand. This will be discussed further later.

Figure 7: *Crashworthiness by year of manufacture (with 95% confidence limits) for all vehicles (both new vehicles and used imports).*

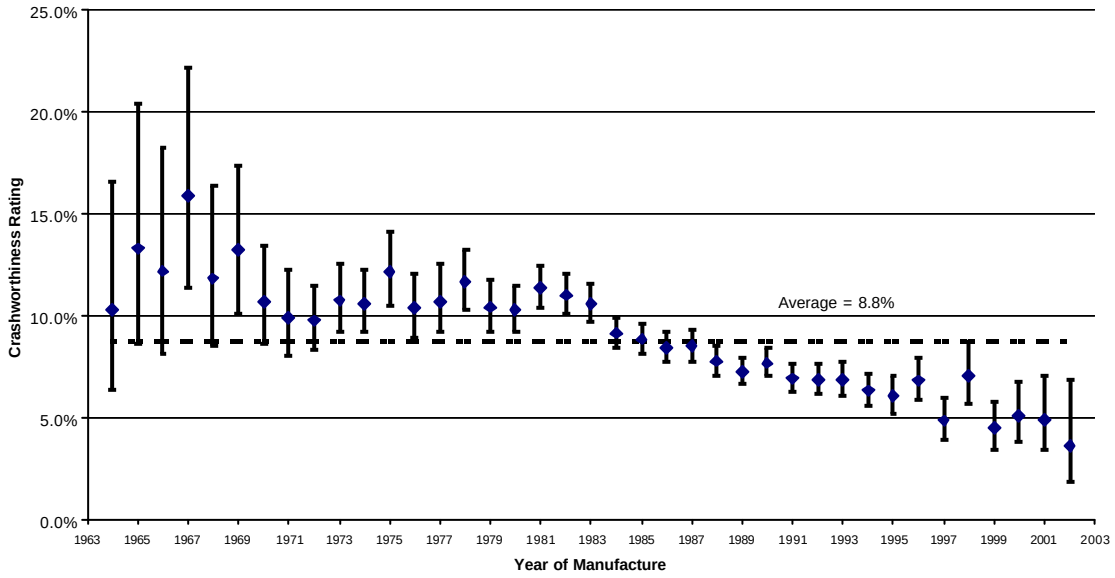


Figure 8: *Crashworthiness by year of manufacture (with 95% confidence limits): Vehicles sold new in New Zealand*

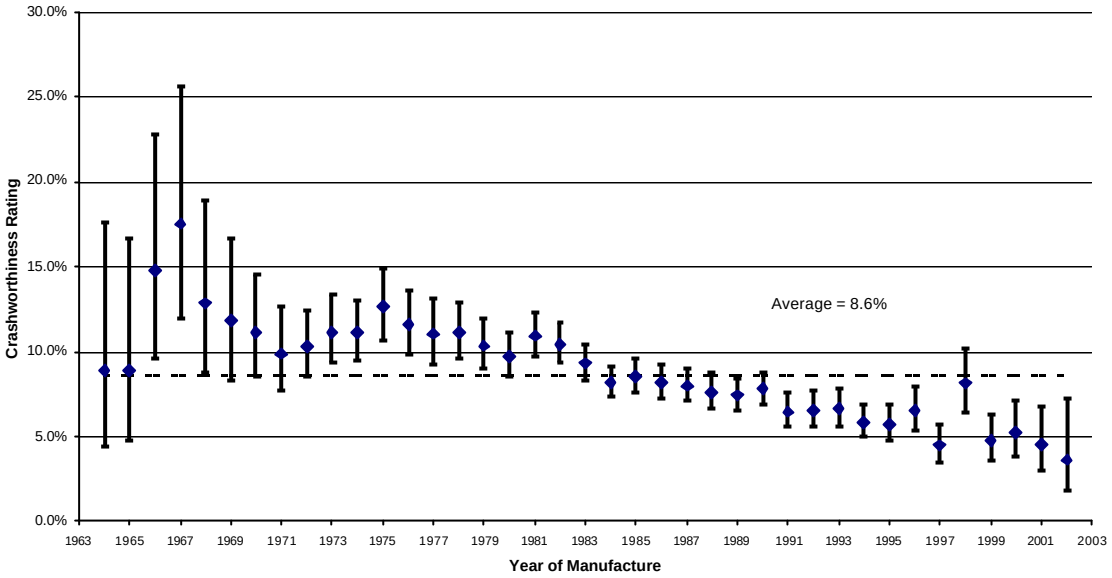
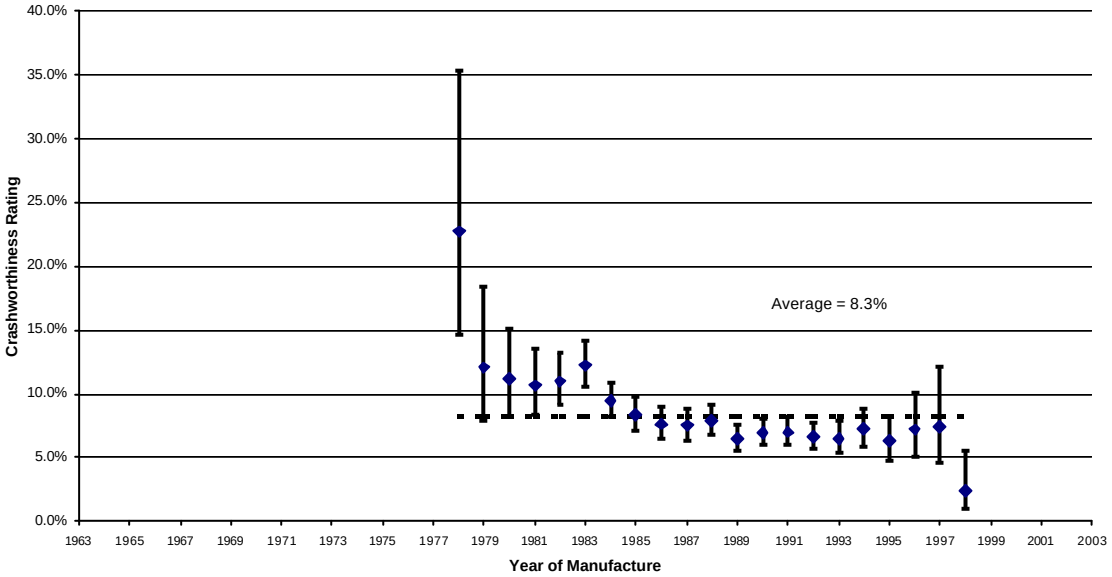


Figure 9: *Crashworthiness by year of manufacture (with 95% confidence limits): Used Imports*



4.2 Crashworthiness by Year of First Registration in New Zealand

A further analysis that is of great interest with respect to the used import program in New Zealand is the crashworthiness of the used-import subset of the vehicle fleet by year of first registration in New Zealand. The purpose of this analysis was to monitor trends in the average crashworthiness of used imports coming into New Zealand by year of import. This is in contrast to the year of manufacture analysis which examines trends in crashworthiness-related safety engineering improvements in vehicles over time.

Analysis of crashworthiness by year of first registration in New Zealand was carried out in the same way as for the year of manufacture analysis. The only fundamental difference was that the variable indicating year of manufacture in the analysis was replaced by the variable indicating year of first registration. Analysis by year of first registration in New Zealand has focused primarily on used import vehicles as the year of manufacture and first registration in New Zealand will generally be the same for vehicles sold new in New Zealand. To quantify the trends in safety of all new and used vehicles registered in New Zealand in each calendar year, an analysis of crashworthiness by year of first registration for all vehicles has also been undertaken.

4.2.1 Injury Risk by Year of first Registration in New Zealand

Injury risk was estimated from the data on 63,010 drivers involved in a two-vehicle collision during 1991 to 2002 where the other driver was injured. This is the same data used for the analysis by year of manufacture. Because of missing values of some of the factors to be included in the logistic regression, and the exclusion of pre-1964 vehicles and unknown years of first registration, analysis was performed on data relating to 26,924 involved drivers, 11,510 of who were injured. For used imported vehicles, analysis was performed on data relating to 8,728 involved drivers, 3,631 of who were injured.

The following terms were statistically significantly associated with injury risk in the covariate models for the analysis of all vehicles and used imports.

Vehicle Class	Base effect terms	First order interactions
Used imports	*Age*	
	Sex	
	Speedzone	
	Year (of crash)	
All vehicles	*Age*	*Sex*Speedzone*
	Sex	*Year*Speedzone*
	Speedzone	
	Year (of crash)	

The resulting estimates of injury risk by year of first registration for used imports and all vehicles are plotted along with 95% confidence limits in Figures 10 and 11 respectively. Full details of the estimates are given in Appendices 9 and 11 respectively.

Figure 10: *Injury risk by year of first registration in New Zealand (with 95% confidence limits): Used imports.*

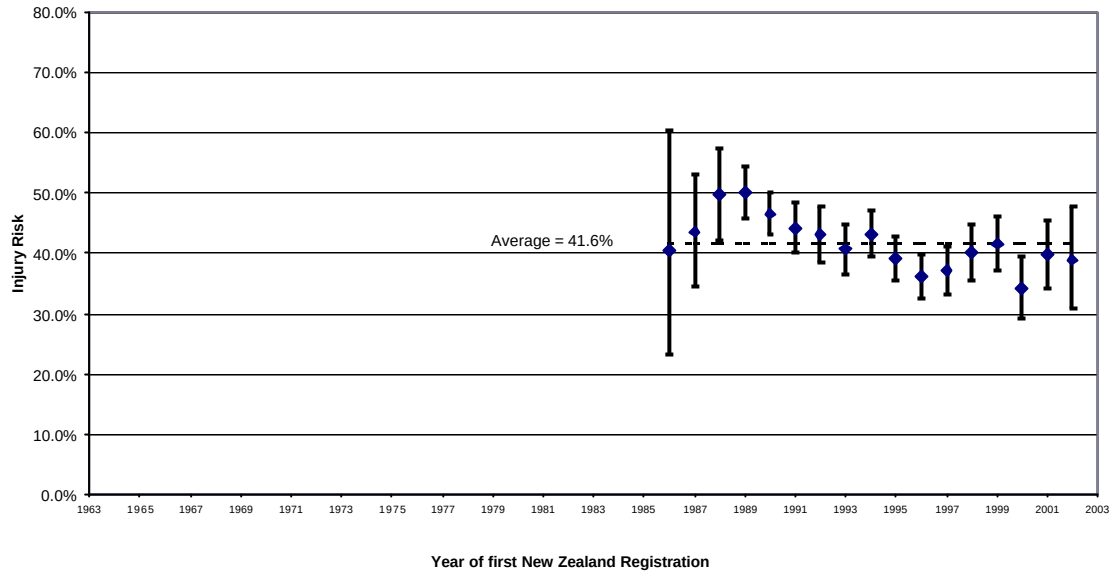
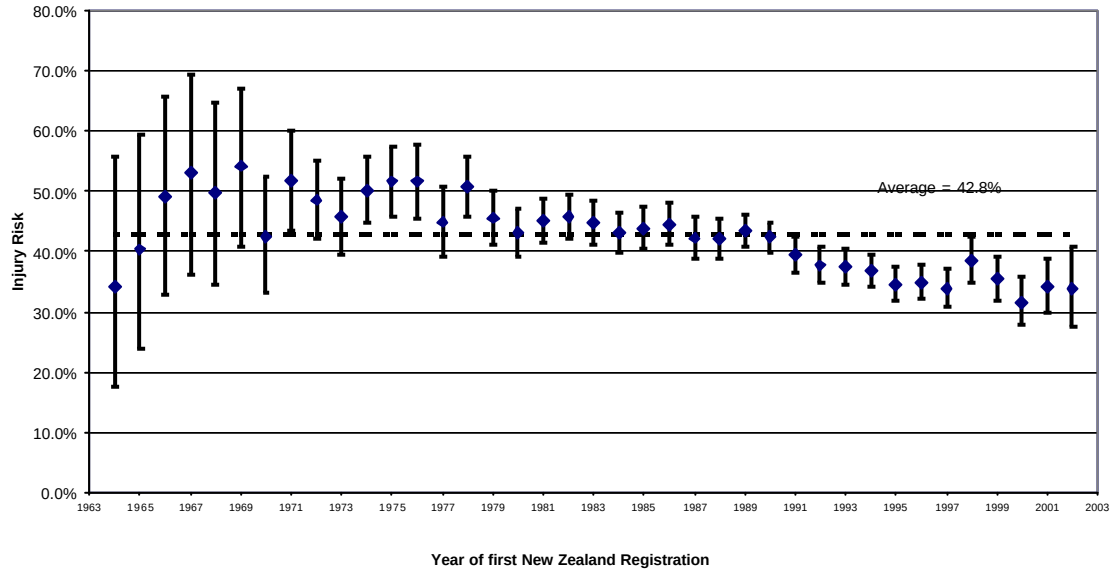


Figure 11: *Injury risk by year of first registration in New Zealand (with 95% confidence limits): All Vehicles, both new vehicles and used imports.*



4.2.2 Injury Severity by Year of first Registration in New Zealand

Injury severity by year of first registration in New Zealand was estimated from the data on 142,723 injured drivers who were injured in crashes in New Zealand during 1991-2002 as used in the analysis by year of manufacture. After exclusion of cases with missing values of some of the associated crash factors and the exclusion of pre-1964 vehicles and unknown years, logistic regression was performed on data relating to 61,366 injured drivers 11,909 of who were severely injured (killed or admitted to hospital). For used import vehicles, analysis was performed on data

relating to 18,460 injured drivers, 3,515 of whom were severely injured. Covariates and interactions included in the injury severity logistic regression model are as follows.

Vehicle Class	Base effect terms	First order interactions
Used imports	*Age*	*Speedzone*Year*
	Sex	*Sex*Nveh*
	Speedzone	
	Nveh	
	Year (of crash)	
All vehicles	*Age*	*Speedzone*Nveh*
	Sex	*Age*Sex*
	Nveh	*Age*Nveh*
	Speedzone	*Age*Speedzone*
	Year (of crash)	*Sex*Nveh*

The resulting estimates of injury severity by year of first registration for used imports and all vehicles are plotted along with 95% confidence limits in Figures 12 and 13 respectively. Full details of the estimates are given in Appendices 9 and 11 respectively.

Figure 12: *Injury severity by year of first registration in New Zealand (with 95% confidence limits): Used Imports.*

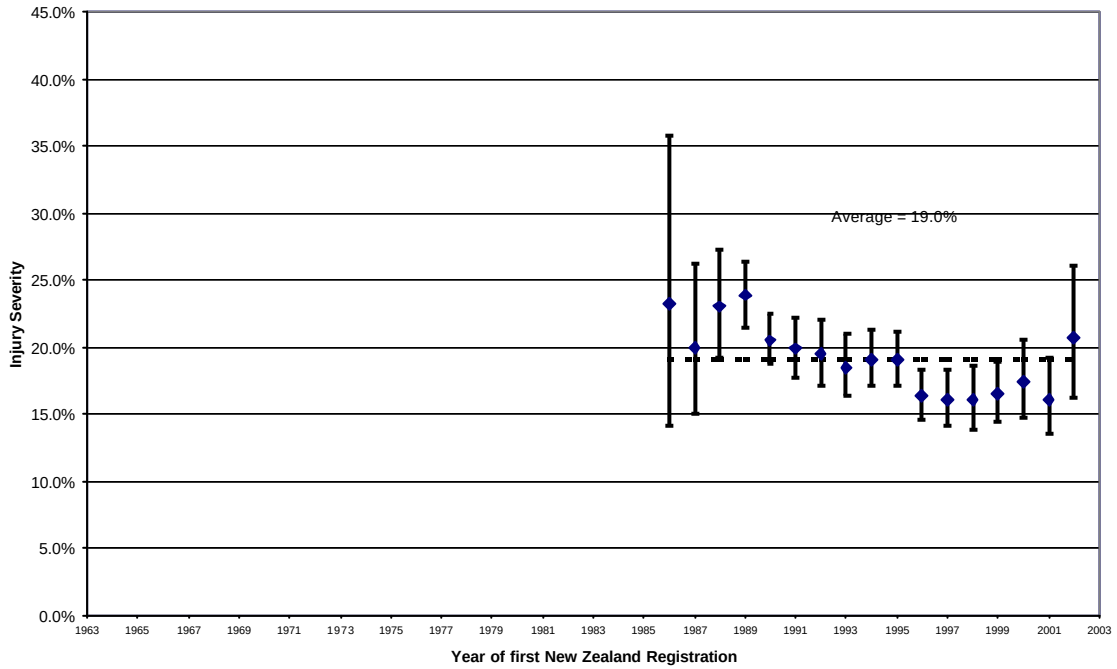
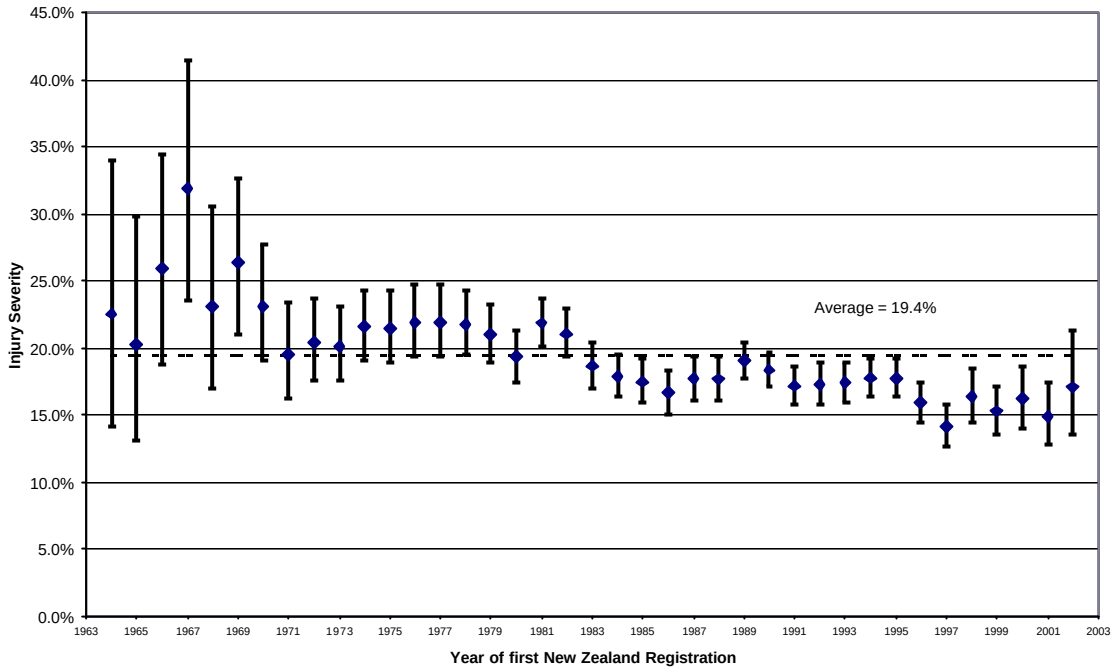


Figure 13: *Injury severity by year of first registration in New Zealand (with 95% confidence limits): All Vehicles, both new vehicles and used imports.*



4.2.1 Crashworthiness by Year of First Registration in New Zealand

Estimates of crashworthiness by year of vehicle first registration in New Zealand were obtained by multiplying the corresponding estimates of injury risk and injury severity presented previously for each of the vehicle groupings considered. The resulting crashworthiness estimates and their 95% confidence limits are presented in full in Appendices 9 and 11 for used imports and all vehicles respectively. Plots of the estimates and their 95% confidence limits are in Figures 14 and 15 respectively. Interpretation of the estimates is the same as for the analysis by year of manufacture presented previously.

Figure 14: *Crashworthiness by year of first registration in New Zealand (with 95% confidence limits): Used Imports*

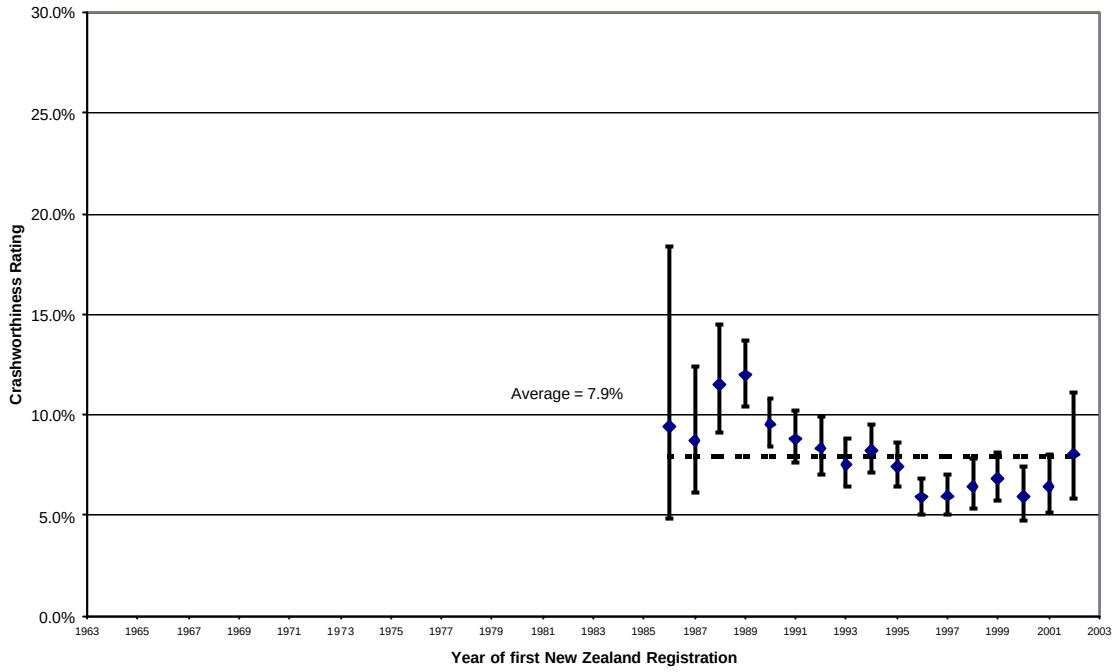
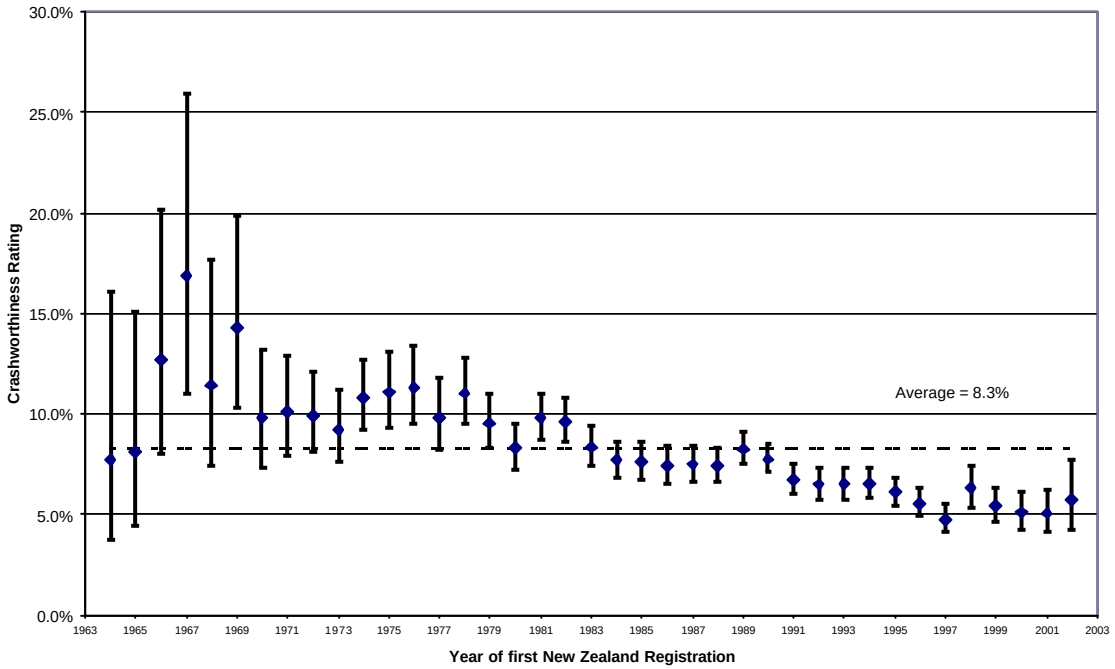


Figure 15: *Crashworthiness by year of first registration in New Zealand (with 95% confidence limits): All Vehicles, both new vehicles and used imports.*



5. DISCUSSION

Analysis presented in this report has been able to quantify the long-term trends in the crashworthiness of light passenger vehicles in New Zealand both by year of vehicle manufacture and

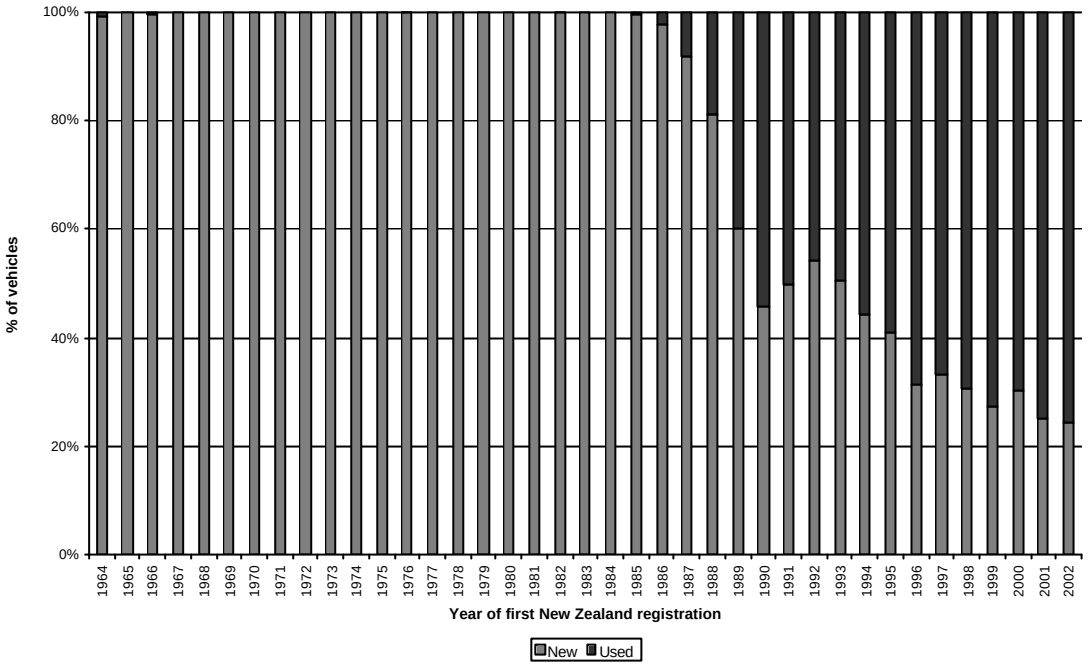
year of first registration in New Zealand. Estimates have been obtained for the light passenger vehicle fleet as a whole, as well as being broken down by vehicles sold new in New Zealand and used imported vehicles. Before interpreting the results of the analysis, it is useful to give a brief summary of the history of the vehicle industry and its regulation in New Zealand.

For most of the twentieth century, starting with the General Motors assembly plant in 1926, New Zealand had a local vehicle industry. In the late 1980s, however, the face of the industry changed dramatically as a result of the progressive removal of import controls from all automotive products and reduction of tariffs on both vehicles and components. There seem to have been a number of motivating factors for the Government decision to allow used vehicles to be imported into New Zealand. One was to provide a wider source of relatively new and relatively affordable vehicles for New Zealand consumers (which in turn put pressure on new-vehicle prices). The need for this was highlighted by a trend towards an ageing vehicle fleet in New Zealand at that time. Another motivation for the used import program was to attempt to reduce the number of motorcycles in the New Zealand fleet. New motor cycle registrations had been at a high level during the 1970s and early 1980s and they were known to be a less safe means of transport than a car.

The 1990s saw a boom in the sale of used import vehicles in New Zealand along with a corresponding decline in the sales of new vehicles. Figures quoted in TRC(2002) show the percentage of used imports in annual vehicle registrations from 1960 to 1986 was generally well less than 10%. The period from 1987 onwards saw a sharp rise in this percentage and by 2002 around 68% of all vehicle registrations in a year were used imported vehicles. Annual registrations of vehicles sold new in New Zealand have shown a corresponding decline over the period from around 90,000 units in the early 1980s to around 60,000 units by the early 2000s. Under these economic constraints, by the late 1990s the local light-vehicle assembly industry had ceased operation.

The increase in the percentage of used import vehicle registrations in New Zealand is also reflected in crash data summaries such as LTSA(2002). Illustrating this point, Figure 16 plots the proportion of used import vehicles crashing in New Zealand over the period 1991 to 2002 by year of first registration in New Zealand derived from the data analysed in this study. The proportion of crashed vehicles by year of first registration in New Zealand that are used imports generally follows the trends expected from the registration statistics with rapid growth between 1987 and 2002.

Figure 16: *Percentage of vehicles sold new in New Zealand and imported used by year of first registration in New Zealand in the 1991-2002 crash data.*



The vast majority of the used light passenger vehicles imported into New Zealand come from Japan. Indeed, around 75-80% of all new registrations of both new and used vehicles in New Zealand are Japanese vehicles with Australian vehicles the next most prevalent at around 8% of new vehicle registrations.

Like most countries, New Zealand has a system of regulations to govern the safety of vehicles on the road. The earliest of these were the Traffic Regulations 1936 (TR36), updated in 1954 (TR54) and 1976 (TR76). For many years, the general focus of the Traffic Regulations was to set requirements for vehicles built in New Zealand. However, a separate set of regulations governing vehicle standards was developed in order to align New Zealand legislation with that of standard-setting bodies in the safety-conscious jurisdictions overseas from which the vehicles were sourced, namely Australia, Japan, UN/ECE and the USA. These Transport (Vehicle Standards) Regulations (1990) (VSRs) set out the technical standards with which motor vehicles must comply in order to be registered in New Zealand.

Over the period since 1990, the vehicle standards policy in New Zealand has been clarified by Government in consultation with the vehicle industry using the consultative rule-making procedure, and today the VSRs have been replaced by Land Transport Rules covering standards and safety requirements. In addition, the important Compliance Rule sets out requirements for inspection and certification of vehicles to ensure they meet the safety requirements at import and when on the road in New Zealand. Details of the vehicle standards requirements and legislation are available on the Land Transport New Zealand web site (www.landtransport.govt.nz)

It is with this history of vehicle safety standards regulation in New Zealand in mind that the analyses presented in this report should be interpreted. Because the analysis presented in this study is based on a census of all reported injury crashes in New Zealand over the period 1991 to 2002, they can

be considered as representative estimates of the trends in secondary safety performance of the entire light passenger vehicle fleet in New Zealand.

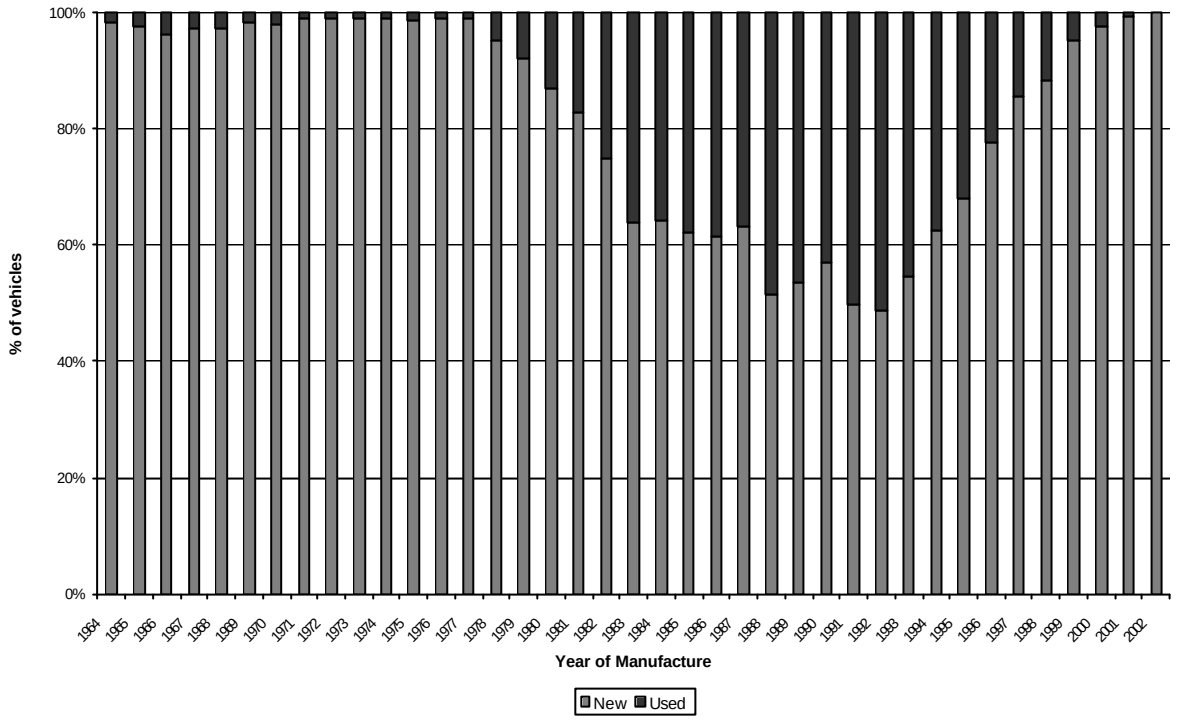
5.1 Trends by Year of Manufacture

Trends in estimated crashworthiness by year of vehicle manufacture for the New Zealand light passenger vehicle fleet as a whole show statistically significant improvement in crashworthiness in vehicles manufactured over the period 1964 to 2002. Estimates in Figure 7 show that the crashworthiness of vehicles manufactured in the 1960s was relatively poor, although the confidence limits on these estimates are relatively wide due to the small numbers of these vehicles in the available data. For vehicles manufactured during the 1970s, the crashworthiness estimates are relatively static showing no trend to improving or worsening crashworthiness. From about 1984 onwards, however, there is a consistent trend to improving crashworthiness by year of vehicle manufacture in the New Zealand fleet. Estimates suggest that the risk of driver death or serious injury in a crash in a vehicle manufactured in the early 21st century is about half that of the driver of an early 1980s vehicle.

As described above, major legislative change in New Zealand governing vehicle safety standards only started to come into force from around 1990 through the VSRs and Land Transport Rules, particularly the Compliance Rule, which required proof of standards compliance if a vehicle was to enter the NZ fleet. It is also important to note that there was a revision to the Frontal Impact Rule on 1 April 2002, which now requires that a Class MA vehicle (passenger car) must have been manufactured in accordance with an approved frontal impact standard if it is to enter the New Zealand fleet. (Frontal impact protection systems of course contribute to improving vehicle crashworthiness). The crashworthiness ratings for 2002 onwards cannot yet be calculated but it will be interesting to see if there is a change in the ratings corresponding to the introduction of the revised rule.

The estimates of vehicle crashworthiness by year of manufacture for the New Zealand fleet as a whole are an average of the estimates for vehicles sold new and the used imports. The average is weighted from the number of each registration type crashing for each year of manufacture. Figure 17 shows the percentage of crashed vehicles, both sold new in New Zealand and imported second hand, by year of manufacture. The data in Figure 17 reflects both the averages of the crash data period (1991-2002) as well as the fact that used import vehicles are older when bought into New Zealand and hence older on average when they crash. This is why the proportion of later model vehicles crashing increases from around 1993 in Figure 17.

Figure 17: *Percentage of crashed vehicles sold new in New Zealand and imported used by year of manufacture in the 1991-2002 crash data.*



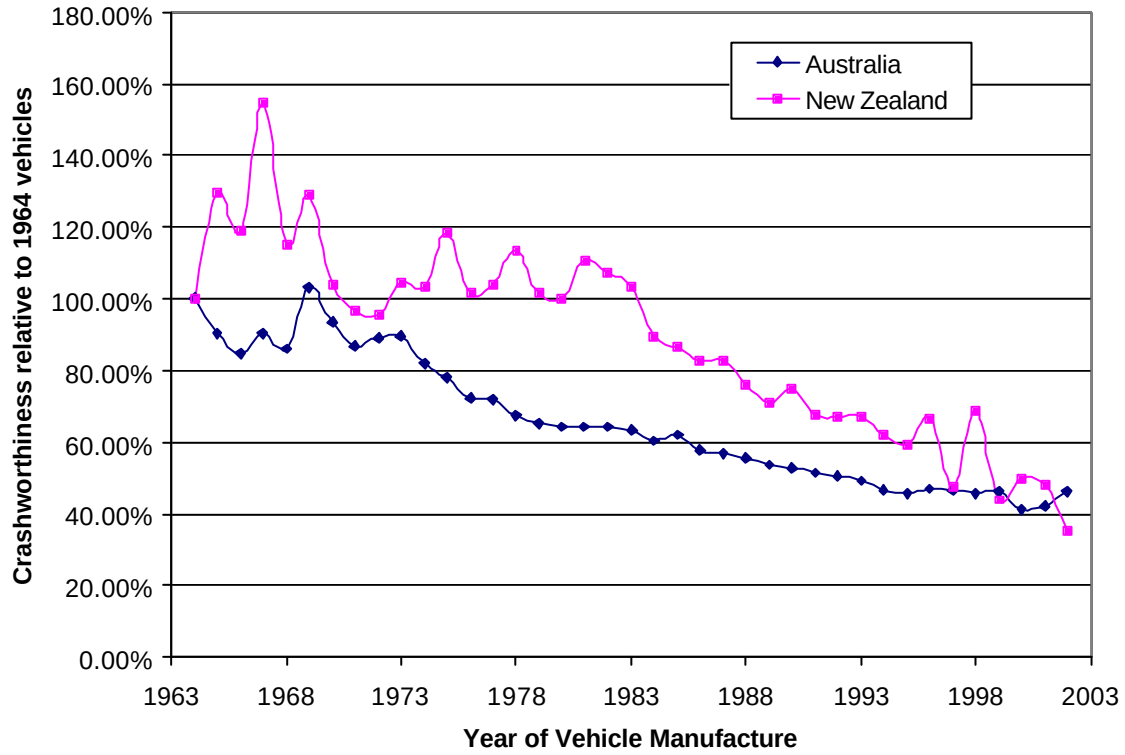
Trends in crashworthiness for vehicles sold new in New Zealand and imported used, shown in figures 8 and 9 respectively, are similar for the two vehicle groups. They both show evidence of a trend towards improving crashworthiness with later year of manufacture over the years 1978 to 1998 for which estimates are available for both vehicle groups. In both instances, average crashworthiness improved from around 11-12% in the late 1970s to around 6-7% in the late 1990s, a relative improvement of around 40% over the period. The similarity of the results for the different vehicle groups suggests that both increased safety regulation and general safety engineering improvements in vehicles appear to have had the same benefits for used imports as for vehicles sold new in New Zealand, when assessed on a year of manufacture basis. It also confirms that, on a year of manufacture basis, the level of secondary safety in used imported vehicles now appears to be equivalent to that found in vehicles sold new in New Zealand.

Because of the relatively high similarity between the types of vehicles in the Australian and New Zealand vehicle fleets, it is interesting to compare the relative trends in safety improvement between the vehicle fleets of the two countries. This comparison is also of interest to determine if the quite different strategies for vehicle safety regulation adopted in the two countries have led to fundamental difference in the patterns of vehicle safety improvement from year to year. One difficulty in making this comparison occurs because the measure of crashworthiness by year of manufacture used in each jurisdiction was scaled differently, reflecting the differences in the available data. Unfortunately the estimates from each country cannot be scaled to a common basis for comparison because the average absolute injury risk cannot be calculated from the injury-only crash data available from New Zealand. This means that comparisons between absolute crashworthiness cannot be made between the two countries. However, because the analysis method used here provides unbiased estimates of relative crashworthiness between each year of manufacture, as does the method used to analyse the

Australian data, comparisons in relative changes in crashworthiness by year of manufacture can be made between the two countries.

The relative change in crashworthiness by year of vehicle manufacture using 1964 as the base year is shown in Figure 18 for both Australia and New Zealand. Crashworthiness by year of vehicle manufacture in Australia showed an improvement of around 30% between the end of the 1960s and the end of the 1970s in response to the introduction of a program of new Australian Design Rules concerning vehicle safety. After a relative plateau in the early 1980s a further steady improvement of about 25% in vehicle crashworthiness has been estimated between 1985 and 2002. This means that the average risk of death or serious injury to a driver in a crash in an Australian vehicle manufactured in 2002 is on average about half that of a vehicle manufactured in the 1960s (Newstead et al, 2004). The crashworthiness of New Zealand vehicles manufactured in the 1960s was also poor compared to subsequent years. However, whilst consistent improvement in crashworthiness was seen in vehicles manufactured in the 1970s, New Zealand had little improvement in crashworthiness of vehicles manufactured during the 1970s and first half of the 1980s. Only since years of manufacture from about 1984 has New Zealand seen consistent and dramatic improvements in average vehicle crashworthiness. In fact, the crashworthiness of New Zealand vehicles manufactured from the early 1980s to the early 2000s has improved by about 50%, equivalent to the total improvement seen in Australian vehicles over the period from 1964 to 2002.

Figure 18: *Crashworthiness by year of vehicle manufacture as a percentage of 1964 vehicle crashworthiness: Australia and New Zealand.*



The key difference in crashworthiness improvement by year of vehicle manufacture between Australia and New Zealand then appears not to be the magnitude of the improvement but the relative timing of the improvement. The greatest improvements in Australia were observed during the 1970s,

the period during which the greatest numbers of new regulations concerning vehicle safety were introduced. Although improvements have also been estimated in Australia after these years of manufacture they have occurred at a slower rate. In contrast the greatest improvement in crashworthiness has been observed in New Zealand for vehicles manufactured from the mid 1980s to 2002. This is also the period in which the greatest movement in introducing vehicle safety regulations in the form of the VSRs and Land Transport Rules took place. Estimated trends from both countries suggest that regulation of vehicle standards is one of the best ways to achieve the biggest gains in vehicle safety performance.

As has been noted in analysing safety trends in the Australian vehicle fleet (Newstead and Cameron, 2001), the estimates of crashworthiness by year of vehicle manufacture for any particular year of manufacture reflect the composition of the fleet by market group and specific makes and models in that year. This comment certainly also applies to the analysis of the New Zealand vehicle fleet presented here. From the analysis presented here, it is uncertain what changes in the fleet mix and consumer choice of specific vehicle makes and models have taken place in New Zealand. It is beyond the scope of this study to fully explore this question and further research is recommended to examine the issue.

5.2 Trends by Year of First Registration in New Zealand

Analysis of trends in vehicle crashworthiness by year of first registration in New Zealand has been aimed primarily at the used import vehicle fleet. Specifically, it has aimed to assess the average crashworthiness of second hand vehicles being imported into New Zealand in each calendar year. It further aimed to assess the impact of the second hand import program on the overall safety of all vehicles registered in New Zealand each year.

If the age profile of used import vehicles was fixed for each year of first registration in New Zealand and the vehicle type mix of the used imports reflected that of new vehicles of the same years of manufacture, it would be expected that the estimates of crashworthiness by year of first registration in New Zealand would mirror those of vehicles sold new. The only difference would be a shift in the estimates equal to the average age of the used import vehicles at their time of first registration in New Zealand. Figure 19 shows the distribution of the age of used import vehicles at the time of first registration in New Zealand for all used imported vehicles appearing in the 1991-2002 crash data. Whilst vehicles up to about 12 years old are imported, with some even older than that, the majority of used imports are in the range from 3 to 9 years old when imported, with the median age being around 6 years. Consequently we would expect the crashworthiness by year of first registration curve of Figure 14 to look like the crashworthiness by year of manufacture curve for used import vehicles (Figure 9) translated 6 years to the right.

Figure 19: *Distribution of age of used import vehicles at date of first registration in New Zealand: Vehicles crashed during 1991-2002*

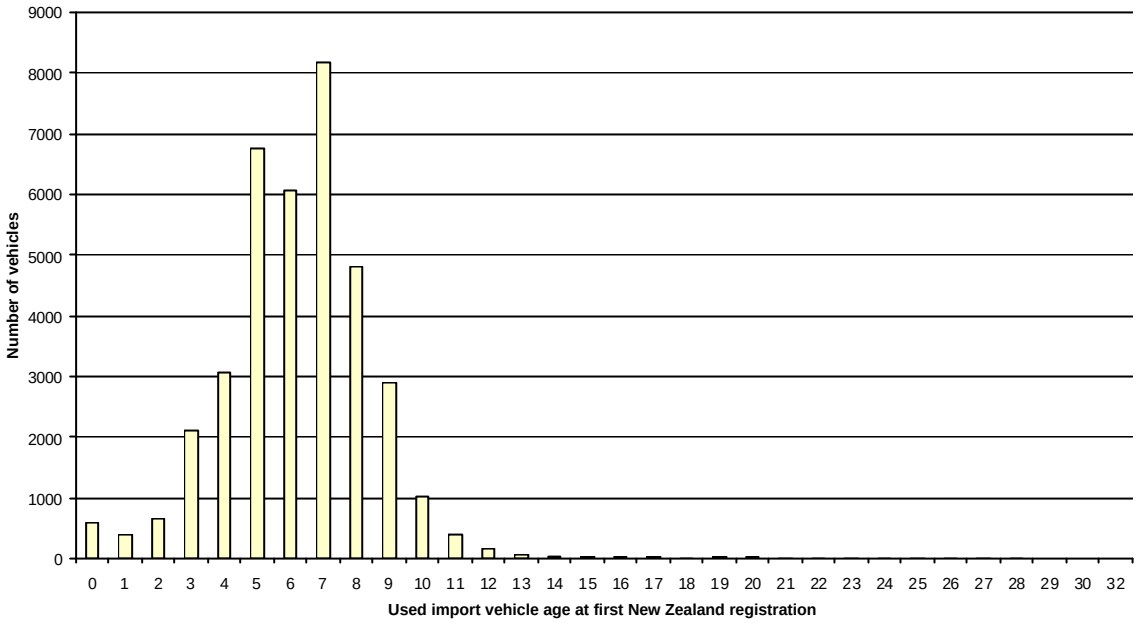
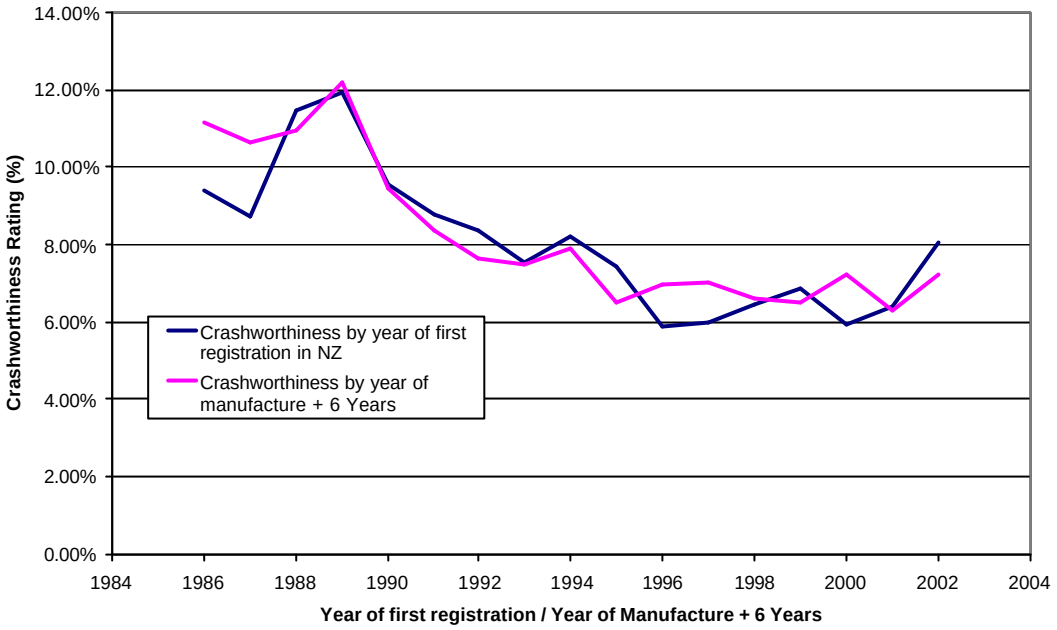


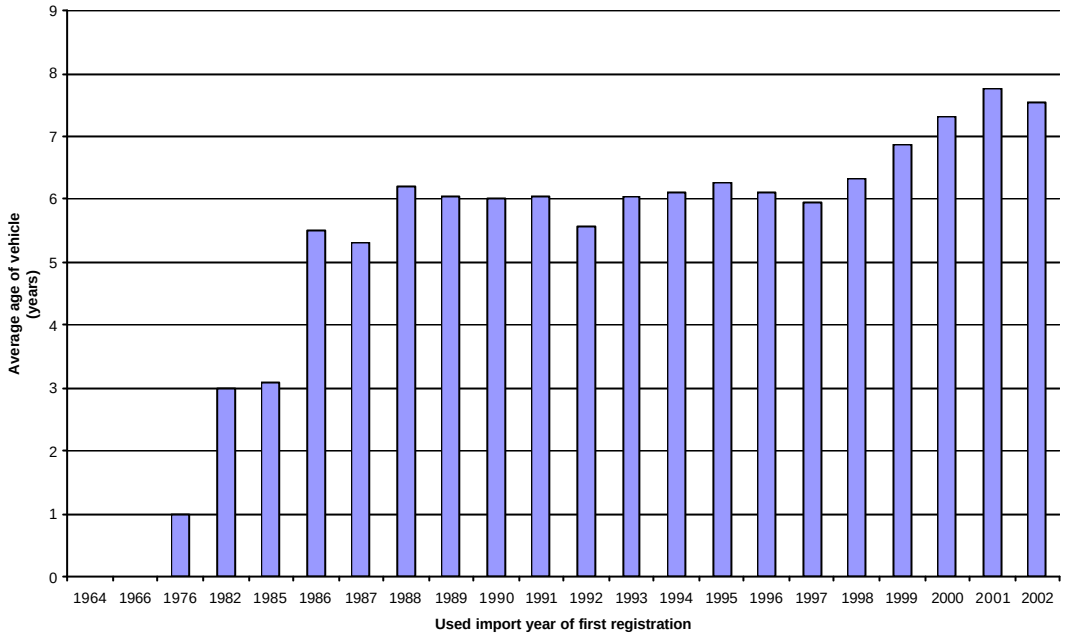
Figure 20 shows the point estimates of crashworthiness by year of first registration in New Zealand superimposed on the estimates of crashworthiness for used imported vehicles by year of manufacture translated 6 years to the right. The two curves are almost identical confirming that the average crashworthiness of used imports brought into New Zealand in any year is the same as the average crashworthiness of new vehicles sold in New Zealand six years earlier. Both curves confirm the trend to improved crashworthiness of used imported vehicles in later years of manufacture with the average serious injury risk to drivers in a crash being reduced by around 40% over the period of the analysis.

Figure 20: *Crashworthiness by year of manufacture translated 6 years forward and Crashworthiness by year of first registration in New Zealand: Used Import Vehicles*



The concordance of the two curves in Figure 20 suggests the average age of the used imported vehicles registered in New Zealand each year has been fairly static. Figure 21 plots the average age of used import vehicles by year of first registration for vehicles appearing in the 1991-2002 crash data. Apart from a slight increase in average vehicle age for vehicles first registered from 1999 onwards, the trend is confirmed to be fairly static with an average age around 6 years. It will be interesting to monitor continued trends in Figure 21. It might be expected that the average age of used imports might decrease from 2002 as a result of changes in the Land Transport Rule concerning frontal impact compliance. From April 2002, all vehicles newly registered in New Zealand must comply with frontal impact occupant protection standards, as compared to only vehicles manufactured from March 1999 in the previous rule. The modified rule will make it difficult to import used vehicles manufactured before 1996, the date after which Japanese domestic vehicles manufactured had to meet the Japanese frontal impact standard accepted under the New Zealand rule. Further research should be carried out to monitor trends in the average age of used import vehicles in New Zealand at time of import.

Figure 21: *Average age of used imported vehicles by year of first registration in New Zealand: Vehicles crashed during 1991-2002.*



What the analysis shows in practice is that the used imported vehicles being brought into New Zealand are as safe on average as the vehicles sold new in New Zealand when compared on a year of manufacture basis. However, because the used vehicles are on average 6 years old when entering the country, the safety benefits of the latest vehicle technologies seems to take 6 years longer to be seen in the New Zealand fleet than if the vehicles were sold new in New Zealand. Given that the proportion of used import vehicles in the total volume of new vehicle registrations has been growing over the last decade or more, a corresponding increased delay in the introduction of latest vehicle safety technology in the New Zealand fleet will be resulting. In other words, the used import program is resulting in a poorer average crashworthiness of all vehicles registered in New Zealand each year compared to the situation where only new vehicles were sold.

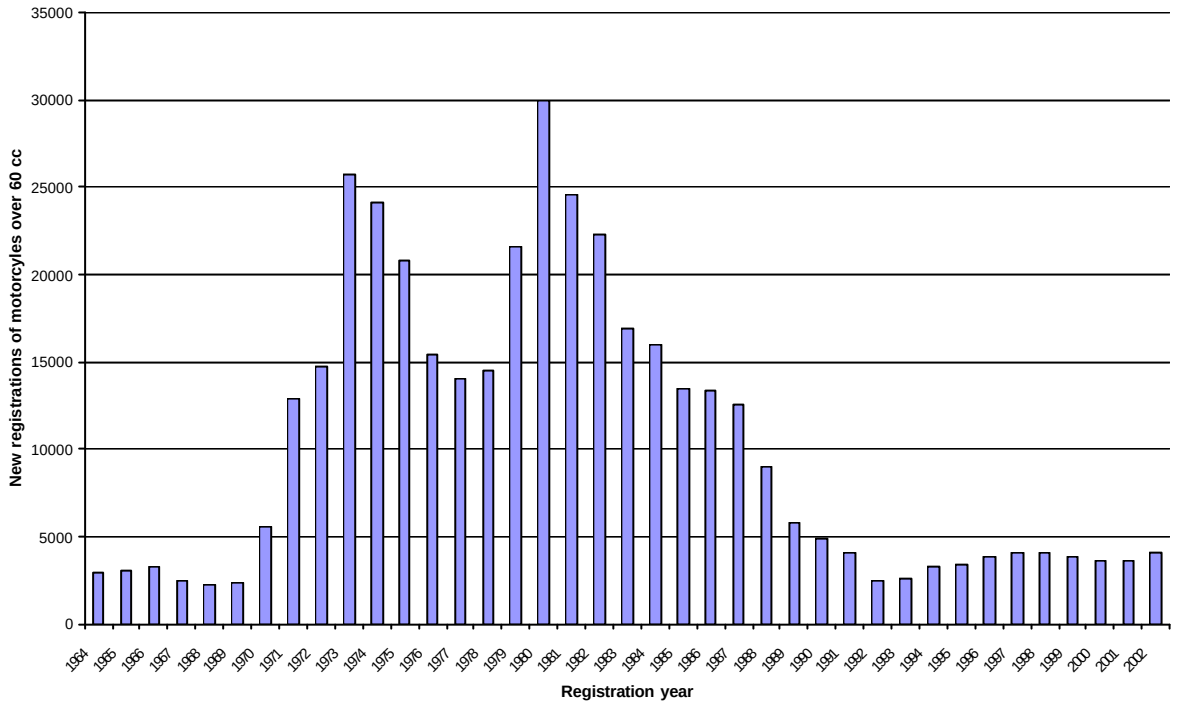
However, before concluding that the used import program is compromising the safety of the New Zealand vehicle fleet, the effect of the used import program on average fleet age must be considered. If the used import program has reduced the average age of the New Zealand vehicle fleet by more than 6 years, there may be some net benefit in the program. A comprehensive investigation of how the used import program has affected the average age of the New Zealand fleet, particularly in the face of increasing motorisation, is beyond the scope of this study but is recommended as further research.

5.3 Effects on Motorcycle Registrations and Crashes

One of the objectives of the used import vehicle program in New Zealand seems to have been to reduce the high motorcycle use the country had seen during the 1970s and 1980s. Consequently, assessing the net impact of the used vehicle import program in New Zealand would not be complete without at least a brief examination of the trends in motorcycle registrations and deaths and injuries resulting from motorcycle crashes in New Zealand.

Figure 22 gives annual motorcycle registrations in New Zealand from 1964 to 2002. After averaging over 15,000 registrations annually during the 1970s and the first half of the 1980s, motorcycle registrations dropped sharply during the late 1980s to a consistent level of less than 5000 per annum from 1991 onwards.

Figure 22: *Motorcycle registrations in New Zealand: 1964-2002*



The drop in annual motorcycle registrations shows a high degree of correlation with the dramatic increase in the proportion of used import registrations in New Zealand from around 1985 onwards. Whilst the evidence of a correlation is not proof that the used import program caused the drop in motorcycle registrations, it is considered likely that this is the case

Corresponding to the drop in motorcycle registrations in New Zealand has been an equally large drop in reported deaths and injuries associated with motorcycles in the official crash statistics. Annual trends in reported motorcyclist injuries and deaths over the period 1991 to 2002 are shown in Figures 23 and 24 respectively. Deaths have dropped from around 70 per annum in the early 1990s to around 30 per annum by 2002 whilst injuries have dropped by the same order of magnitude. The sustained progressive reduction in motorcyclist death and injury during the 1990s was maintained even though new registrations reached a plateau over the period. This is likely due to the total population of motorcycles reducing as older motorcycles were taken off the road but may also in part be due to general road safety improvement in New Zealand over the period.

Figure 23: *Motorcyclist injuries in New Zealand crashes during 1991-2002*

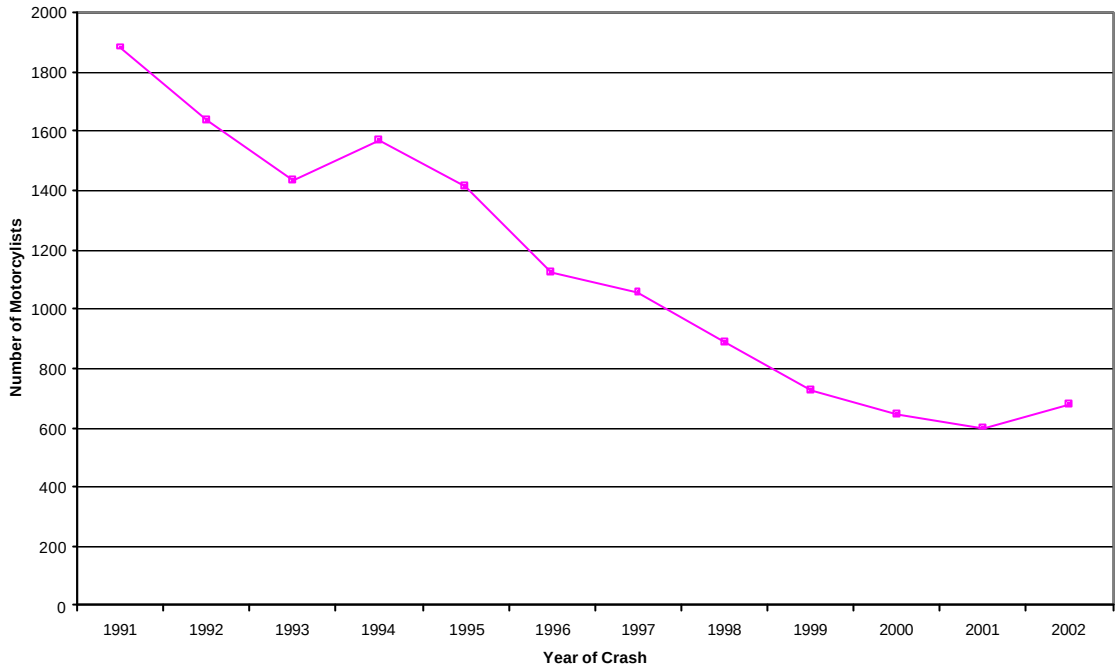


Figure 24: *Motorcyclist fatalities in New Zealand crashes during 1991-2002*

Encouraging road users off motorcycles and into cars may not necessarily reduce the total number of crashes across the system although it is likely given the inherently more stable nature of a car versus a motorcycle. The real benefit in encouraging the use of cars rather than motorcycles is, however, in reducing the severity of injury outcome in the event of a crash (i.e. the crashworthiness of the transport mode). It is a well established fact that cars offer much greater occupant protection in a crash than is afforded to motorcycle riders in a crash. It is beyond the scope of this study to establish the actual net benefits of the used import vehicle program in New Zealand through reduction in

motorcycle use. However, the benefit is likely to be substantial. Further research to establish the full safety benefits of reduced motorcycle usage due to the used import vehicle program in New Zealand is recommended.

5.4 General Discussion

This study has been successful, for the first time, in quantifying trends in crashworthiness of the New Zealand light passenger vehicle fleet both by year of manufacture and year of first registration. Despite the relatively limited quantities of police-reported crash data from New Zealand available for this study, both due to the small population of New Zealand and because only injury crashes are reported, the analysis has been able to identify statistical significant differences in crashworthiness by year of manufacture or first registration in New Zealand. Furthermore, apart from a few early years of manufacture or first registration where data are sparse, the confidence limits on the crashworthiness estimates are not excessively wide, demonstrating the efficacy of the methodology.

The principal reason for the success of the analysis undertaken in this study is the new methodology used. As described, the key feature of the new method is a unique estimator of injury risk from the crash data. The estimator is unique in being unbiased by the underlying aggressivity of the vehicle and can readily be adjusted for the influence of non-vehicle factors on injury outcome via logistic regression techniques. This study is the first time this methodology has been demonstrated in the context of answering a specific research question.

The nature of the new injury risk estimator means it only analyses two-car crashes in which the partner vehicle's driver has been injured, a subset of the total available data. This very selective use of the data may suggest that the estimator may be very inefficient, producing relative injury risk estimates with unreasonably large confidence limits. However, the empirical evidence from the application of the method in this study suggests this is not the case. The confidence limit widths obtained in this study seem to be very much in line with what is expected from other methodology, such as that used to estimate Australian crashworthiness trends by year of manufacture (Newstead et al, 2004), given the available data for this study. Given this, it appears that the new methodology represents a viable alternative for estimating not only crashworthiness and aggressivity trends by year of manufacture, but also vehicle make and model specific crashworthiness and aggressivity ratings from crash databases only including injury crashes.

As was the case with the original study of crashworthiness by year of vehicle manufacture in Australia, this study sets the basis for ongoing monitoring of crashworthiness trends by year of manufacture and first registration in the New Zealand vehicle fleet. Addition of further crash data from years after 2002 as it becomes available will not only allow estimates to be obtained for years beyond 2002 but will also improve the statistical confidence on the estimates for the years covered in this study. Further updating of the study in the future will also provide a mechanism to evaluation the effect of vehicle safety rules and other interventions by the New Zealand Government. For these reasons, it is recommended that this study be updated at regular intervals on an ongoing basis.

It may also be valuable for future research to look at trends in crashworthiness by year of vehicle manufacture in the New Zealand fleet disaggregated by vehicle market group. Such an analysis would offer the potential to give further detailed understanding of the factors driving the overall trends

in crashworthiness of the New Zealand fleet measured in this study. How far the fleet could be broken down in an analysis by market group would depend largely on the available data quantities. Given the results from this study, it is likely an analysis by market group would be possible for at least three or four major vehicle sub-groups.

6. CONCLUSIONS

This study has successfully estimated trends in the crashworthiness of the light passenger vehicle fleet (cars, station wagons, four wheel drives and vans) in New Zealand by both year of manufacture and year of first registration in New Zealand. Crashworthiness is a measure of the relative risk of death or serious injury (hospital admission) to vehicle drivers given involvement in a crash. Years of vehicle manufacture from 1964 to 2002 have been considered through analysis of police reported data on crashes involving injury in New Zealand over the period 1991 to 2002. Estimates have been obtained for the light vehicle fleet as a whole as well as broken down by vehicles sold new in New Zealand and vehicles imported second-hand.

Analysis of trends by year of vehicle manufacture showed statistically significant improvement in the crashworthiness of New Zealand light passenger vehicles over the years of manufacture studied. Most of the measured improvement occurred over the years of manufacture from 1983 to 2002. Over this period, the risk of death or serious injury to drivers in a crash reduced by around 50% for the fleet as a whole. This period corresponded largely with the period over which significant increases in vehicle safety regulation took place in New Zealand. Both levels of absolute crashworthiness and trends on a year of manufacture basis were similar for used imports and for vehicles sold new in New Zealand.

Estimates of crashworthiness trends in the used import subset of the vehicle fleet by year of first registration in New Zealand from 1978 to 1998 showed statistically significant improvements in crashworthiness with time, over the years of first registration analysed. Absolute levels of crashworthiness and improvements by year of first registration paralleled those seen in the analysis by year of manufacture but occurred some 6 years later, a lag equivalent to the average age of the used imported vehicles over the study period.

In practice these results indicate that on a comparable year of manufacture basis used imported vehicles in New Zealand offer similar levels of occupant protection to those sold new. However, because the average age of used imported vehicles in New Zealand is around 6 years, the crashworthiness benefits estimated for new vehicles are not reflected in the New Zealand used import vehicle fleet until 6 years later. As a result, the used import program has led to poorer overall crashworthiness of the New Zealand vehicle fleet compared to what there would have been if all new registrations in a year were of new vehicles. The size of the deficit in crashworthiness performance increased with the proportion of used import sales. This must, however, be considered in the context of the benefits of the used import program in apparently reducing the number of motorcycles in the fleet. Further research is recommended to investigate fully the effects of the used import program on overall injury outcomes in New Zealand

7. ASSUMPTIONS AND QUALIFICATIONS

The results and conclusions presented in this report are based on a number of assumptions and warrant a number of qualifications that the reader should note. These are listed in the following sections.

7.1 Assumptions

It has been assumed that:

- New Zealand Police crash reports accurately recorded driver injury, hospitalisation and death.
- Crashed vehicle registration numbers were recorded accurately on Police crash reports and that they correctly identified the crashed vehicles in the New Zealand vehicle register.
- Vehicle years of manufacture and first registration were accurately recorded in the New Zealand vehicle register.
- The adjustments for driver sex, age, speed zone, the number of vehicles involved and the year in which the crash occurred crash removed the influences of the other main factors available in the data that affected crash severity and injury susceptibility.
- The form of the logistic models used to relate injury risk and injury severity with the available factors influencing these outcomes (including the year of manufacture and first registration) was correct.
- Information contained in the Police crash records allowed accurate matching of both vehicles involved in crashes between two passenger cars for the purpose of calculating injury risk.

7.2 Qualifications

The results and conclusions warrant at least the following qualifications:

- Only driver crash involvements and injuries have been considered. Passengers occupying the same model cars may have had different injury outcomes.
- Other factors not collected in the data (e.g. crash speed) may differ between years of manufacture and first registration and may affect the results. However, earlier analysis has suggested that the different rating scores are predominantly due to vehicle factors alone (Cameron et al 1992a, b).

8 RECOMMENDATIONS FOR FURTHER RESEARCH

A number of key areas for further research have been identified from the results of the analysis presented in this report. They are as follows.

1. It is recommended that the research presented in this report is updated at regular intervals adding additional years' crash data. Regular updates will allow the ongoing monitoring of the secondary safety performance of the New Zealand vehicle fleet as a whole and for new and used imported vehicles separately. Specifically, it will allow the assessment of the impact of both general engineering improvements in new vehicles as well as the impact of regulatory changes on vehicle safety performance in New Zealand.

2. It has been noted in analysing safety trends in the Australian vehicle fleet (Newstead and Cameron, 2001) that estimates of crashworthiness by year of vehicle manufacture for any particular year of manufacture reflect the composition of the fleet by market group and specific makes and models in that year. This also applies to the analysis of the New Zealand vehicle fleet presented here. It is recommended that research be undertaken to investigate the longitudinal changes in the New Zealand vehicle fleet mix in terms of market groups and consumer choice of specific vehicle makes and models in order to establish the effects these changes have had on the overall safety of the fleet. Such research would also look at trends in aggressivity of the New Zealand vehicle fleet by year of manufacture and trends in both crashworthiness and aggressivity by specific market segments as far as possible.

3. Research examining the effect of the New Zealand used import program on average vehicle fleet age is also recommended. Analysis would examine the net effects on safety of the trade off between the average age of the used imported vehicles and the change in average age of the fleet resulting from introduction of the used import. Analysis would necessarily take into account the increasing motorisation of and relative affordability of vehicles to the New Zealand population. Likely safety effects of reducing the average age of used imported vehicles entering New Zealand could also be examined a part of the research.

4. Further research is recommended to investigate the relationship between the introduction and growth of the used import vehicle program in New Zealand and observed reductions in both motorcycle registrations and crashes. Subsequently the net benefits of the used import program on reduced motorcycle trauma could be established.

Research themes 3 and 4 might be best considered in a single integrated project.

REFERENCES

Cameron, M.H., Mach, T., Neiger, D., Graham, A., Ramsay, R., Pappas, M. & Haley, J. (1992a) 'Vehicle Crashworthiness Ratings in Australia', *Proceedings, International Conference on the Biomechanics of Impacts*, Verona, Italy, pp. 105-119.

Cameron, M.H., Mach, T. & Neiger, D. (1992b) *Vehicle Crashworthiness Ratings: Victoria 1983-90 and NSW 1989-90 Crashes - Summary Report*, Report No. 28, Monash University Accident Research Centre, Melbourne, Australia.

Cameron, M.H., Finch, C.F. & Le, T. (1994a) *Vehicle Crashworthiness Ratings: Victoria and NSW Crashes During 1987-92 - Summary Report*, Report No. 55, Monash University Accident Research Centre, Melbourne, Australia.

Cameron, M.H., Finch, C.F. & Le, T. (1994b) *Vehicle Crashworthiness Ratings: Victoria and NSW Crashes During 1987-92 - Technical Report,* Report No. 58, Monash University Accident Research Centre, Melbourne, Australia.

Cameron, M.H., Newstead, S.V., Le, T. & Finch, C. (1994c) *Relationship between vehicle crashworthiness and year of manufacture,* Report No. 94/6 Royal Automobile Club of Victoria Ltd, Melbourne, Australia.

Cameron, M., Newstead, S., Narayan, S. Ernvall, T., Laine, V. and Oppe, S. (2001) 'Comparative analysis of several crashworthiness ratings systems' *CEA/EC SARAC Quality Criteria for the Safety Assessment of Cars Based on Real World Crashes,* EC Directorate General TREN.

Gustafsson, H., Hagg, A., Krafft, M., Kullgren, A., Malmstedt, B., Nygren, A. & Tingvall, C. (1989) *Folksam Car Model Safety Rating 1989-90,* Folksam, Stockholm, Sweden.
Hosmer, D.W. & Lemeshow, S. (1989) *Applied Logistic Regression,* Wiley, New York.

LTSA (2002) *Motor Accidents in New Zealand 2002,* Land Transport Safety Authority, Wellington, New Zealand.

Newstead, S. & Cameron, M. (2001), 'Trends in Australian vehicle crashworthiness by year of vehicle manufacture within vehicle market groups', *Proceedings of the 2001 IRCOBI Conference,* Isle of Man, UK.

Newstead, S., Delaney, A. and Watson, L. (2003) *Vehicle safety ratings estimated from combined Australian and New Zealand real crash data: Pilot Study,* Report No. 203, Monash University Accident Research Centre, Melbourne, Australia.

Newstead, S., Cameron, M. and Watson, L (2004) *Vehicle Crashworthiness Ratings and Crashworthiness by Year of Manufacture: Victoria and NSW Crashes During 1987-2002 Data from Australia and New Zealand,* Report No. 222, Monash University Accident Research Centre, Melbourne, Australia.

SAS Inc. (1989) *SAS STAT Users Guide, Version 6, Fourth Edition, Volume 2.* Carey, NC: SAS Institute.

TRC (2002) *New Zealand Motor Vehicle Registration Statistics 2002* Transport Registry Centre, Land Transport Safety Authority, Palmerston North, New Zealand.

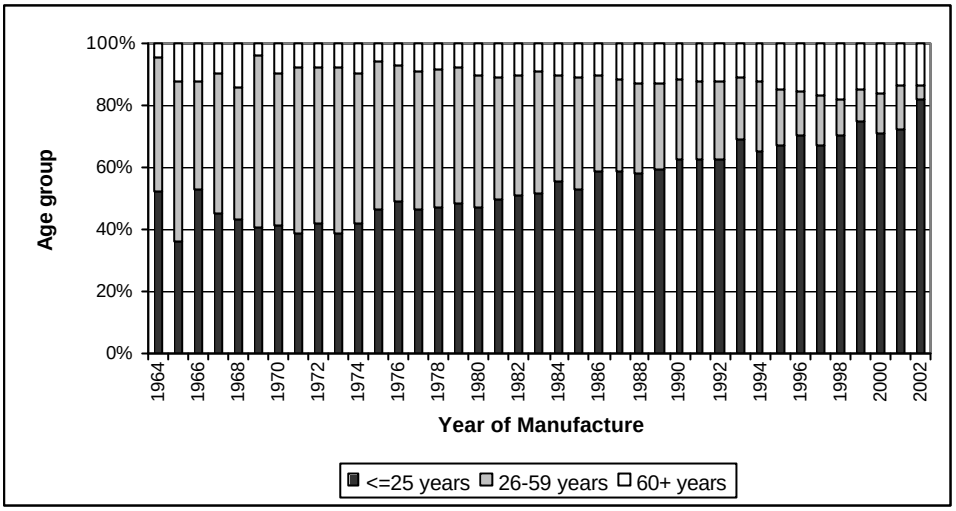
Voyce, T. (2000) *Crashworthiness study - data entry* Land Transport Safety Authority, Wellington, New Zealand.

APPENDIX 1

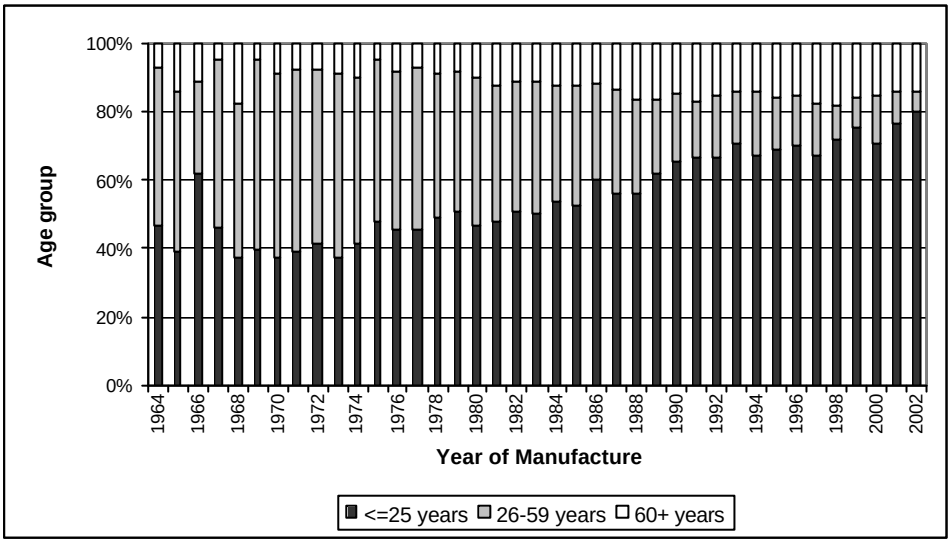
CHARACTERISTICS OF NEW ZEALAND CRASHES DURING 1991-2002

Driver age distribution by year of vehicle manufacture

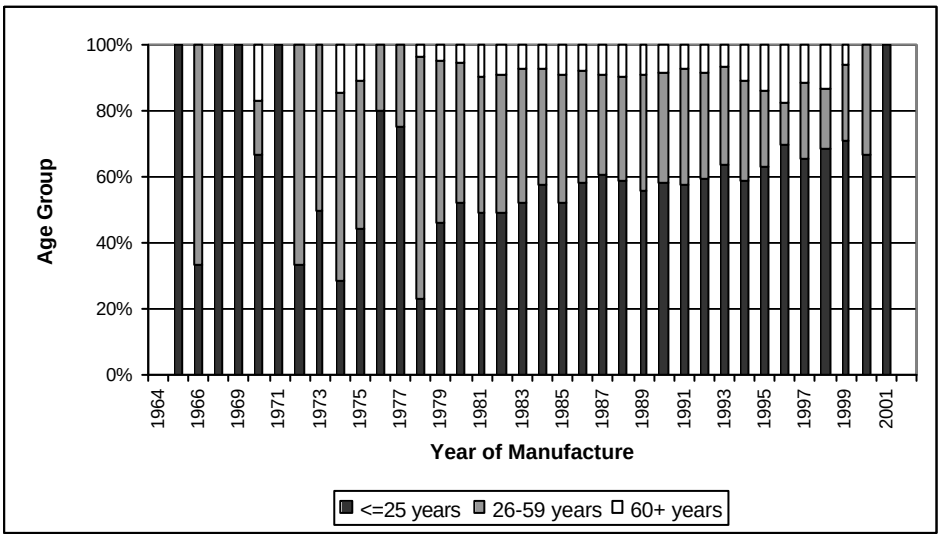
(Drivers Involved in Two-Car Crashes Involving Injury in New Zealand)



All Vehicles



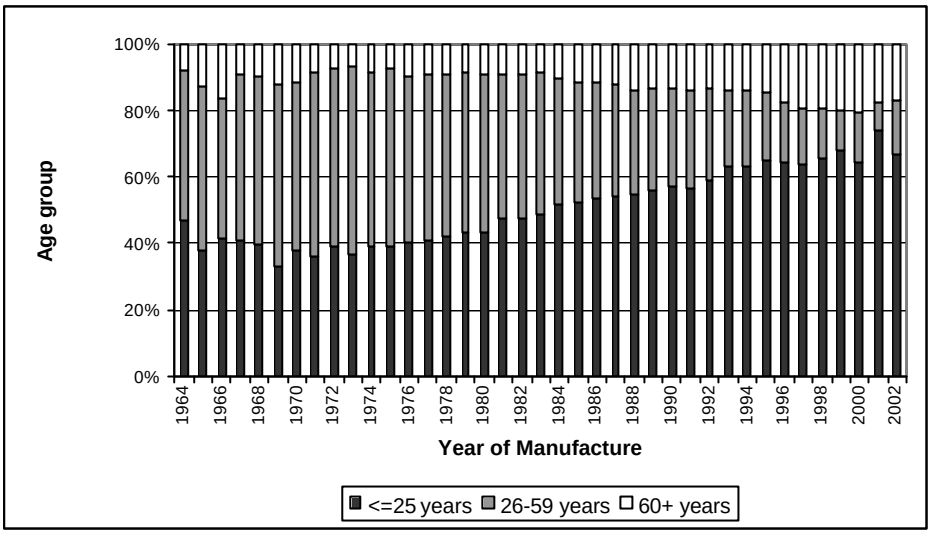
New vehicles



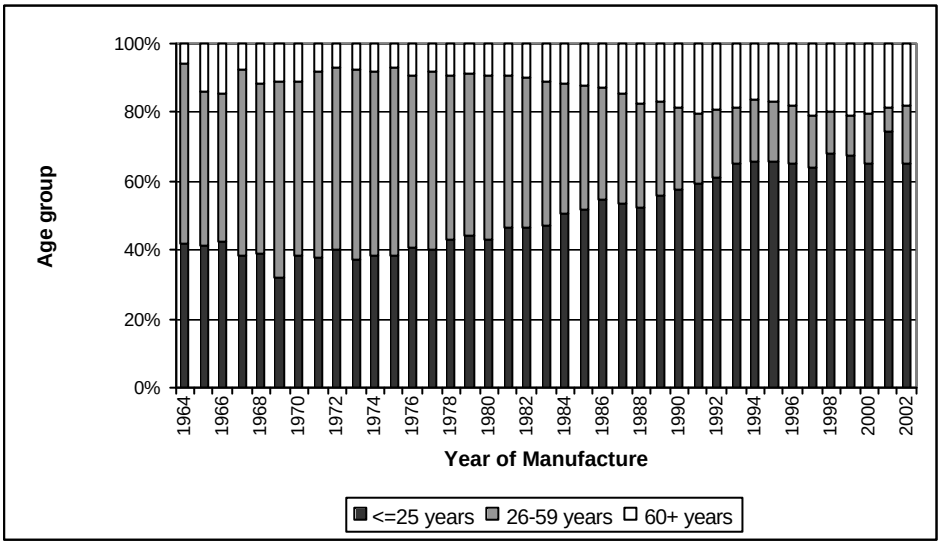
Used Imported Vehicles

Driver age distribution by year of vehicle manufacture

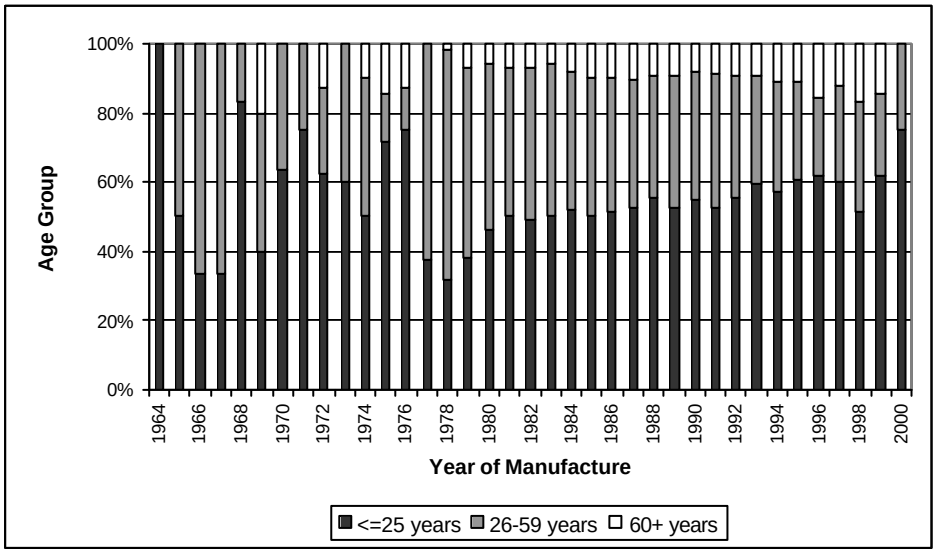
(Drivers Injured in Crashes in New Zealand)



All Vehicles



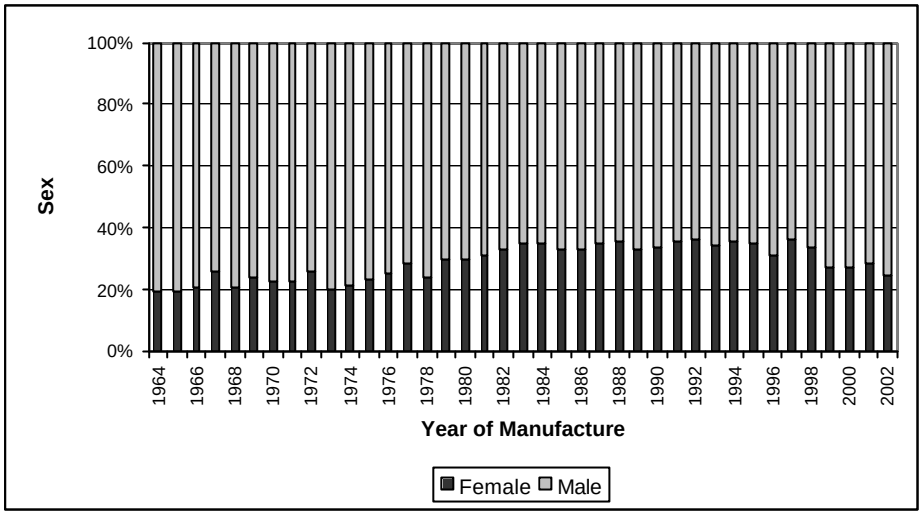
New vehicles



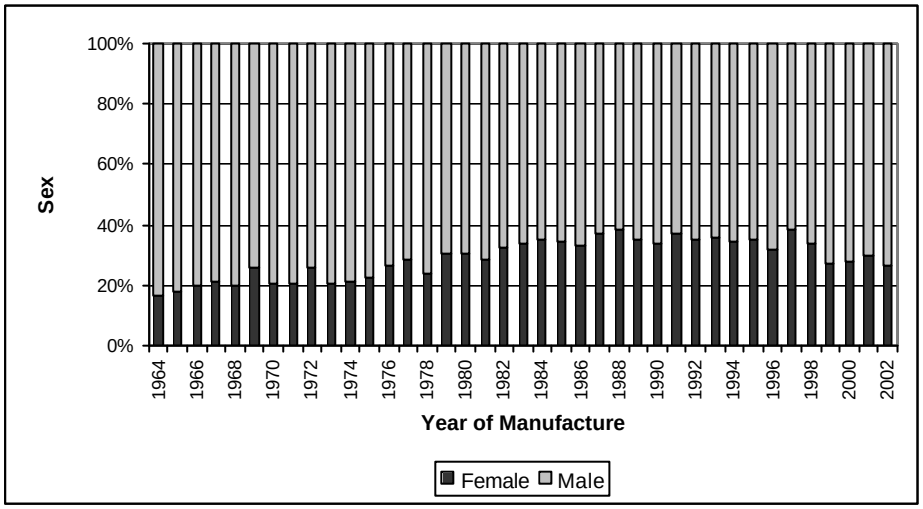
Used imported vehicles

Driver sex distribution by year of vehicle manufacture

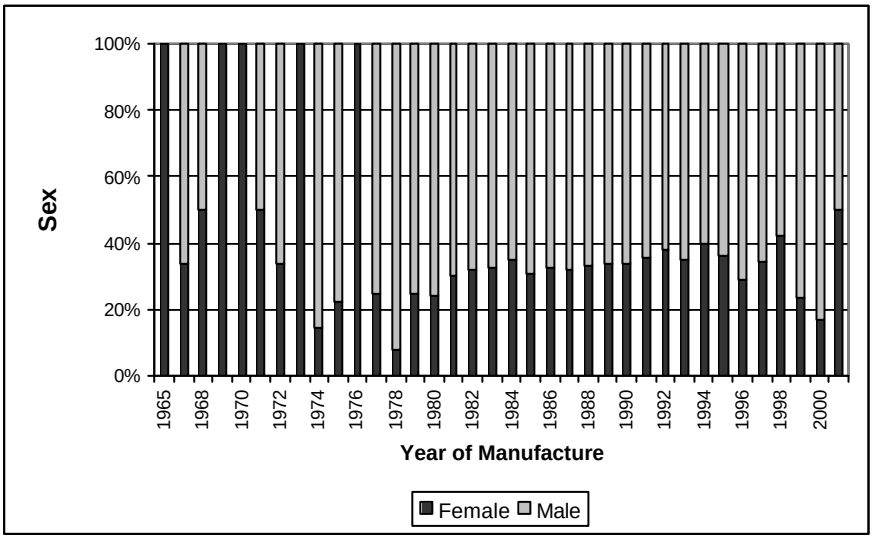
(Drivers Involved in Two-Car Crashes Involving Injury in New Zealand)



All Vehicles



New vehicles

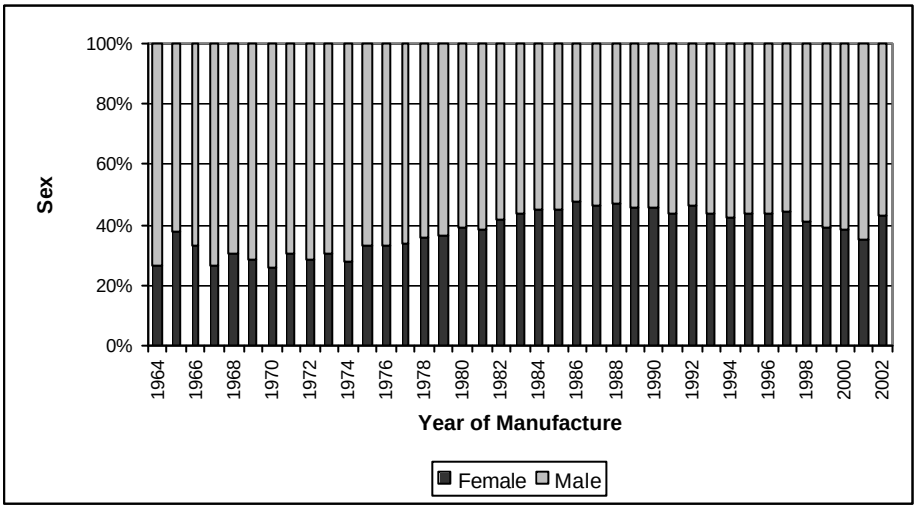


Used imported vehicles

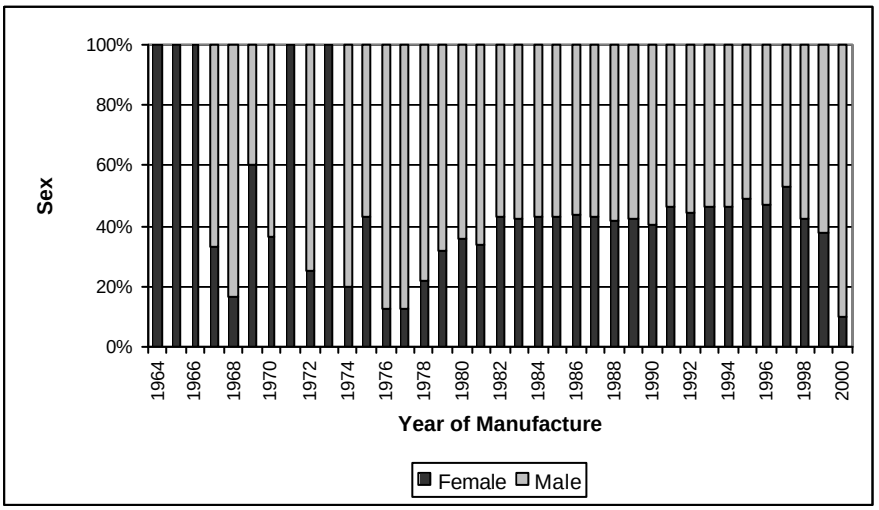
Driver sex distribution by year of manufacture

(Drivers Injured in Crashes in New Zealand)

All Vehicles



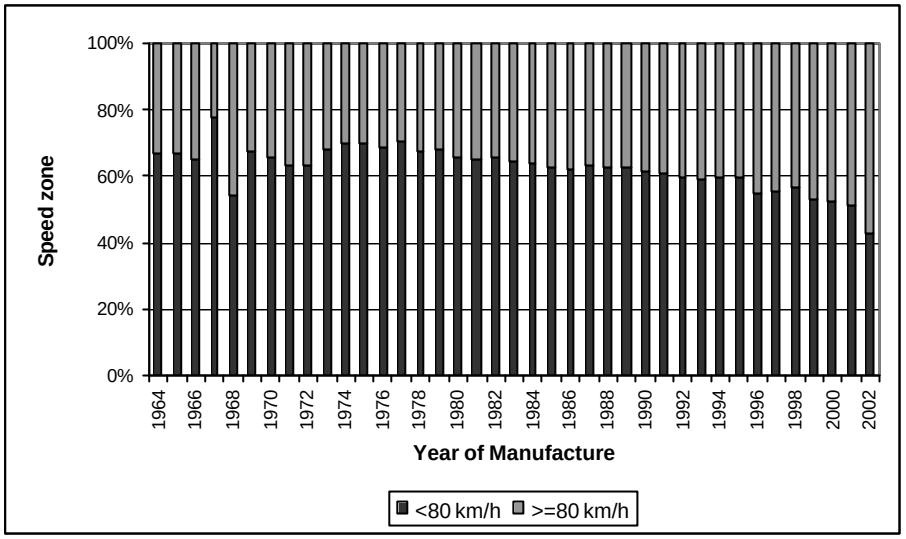
New vehicles



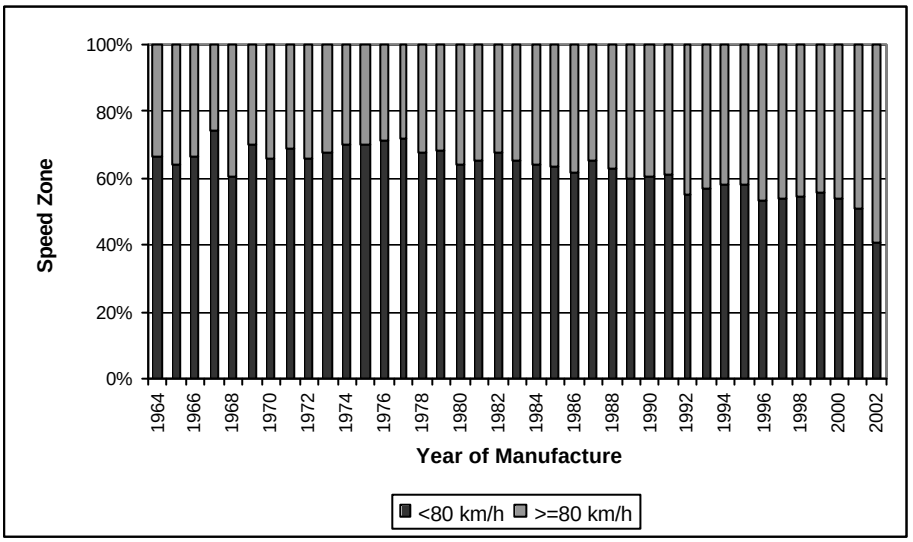
Used imported vehicles

Crash speed zone distribution by year of manufacture

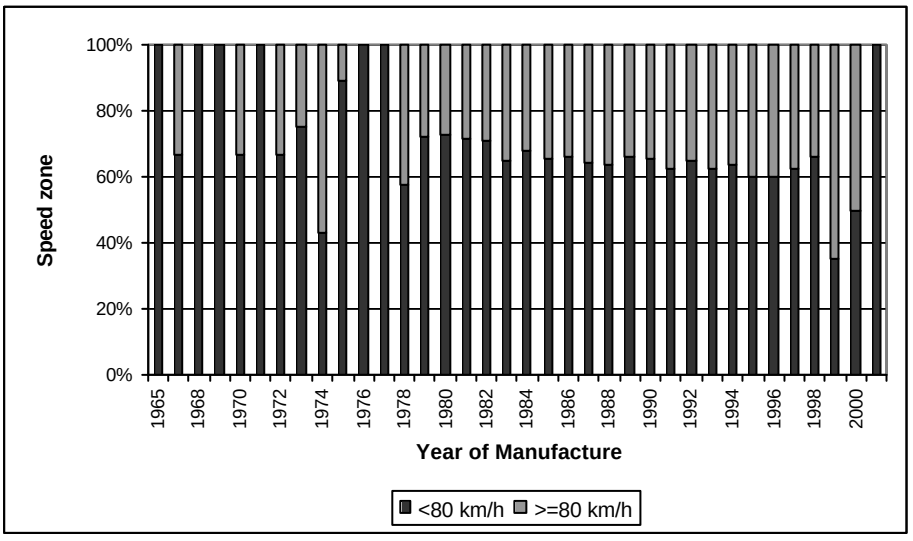
(Drivers Involved in Two-Car Crashes Involving Injury in New Zealand)



All Vehicles



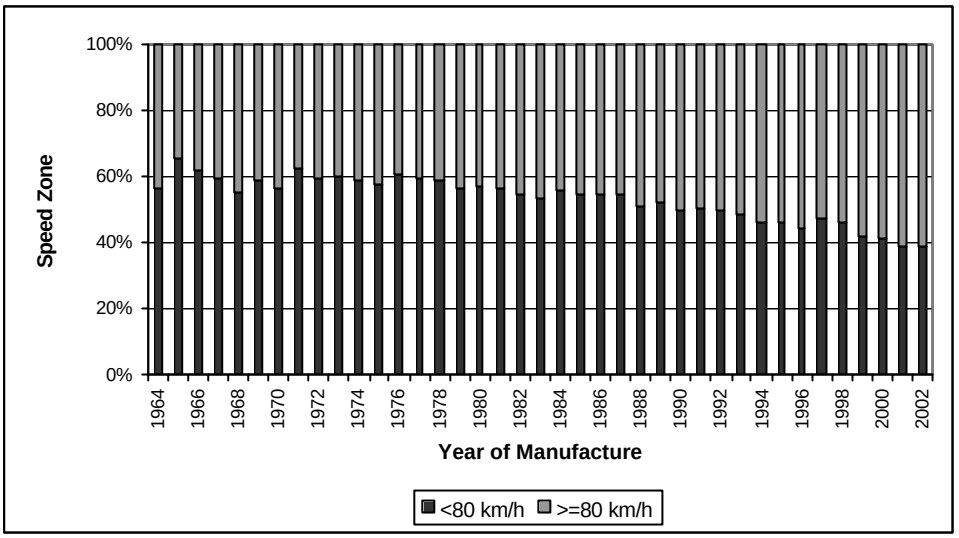
New vehicles



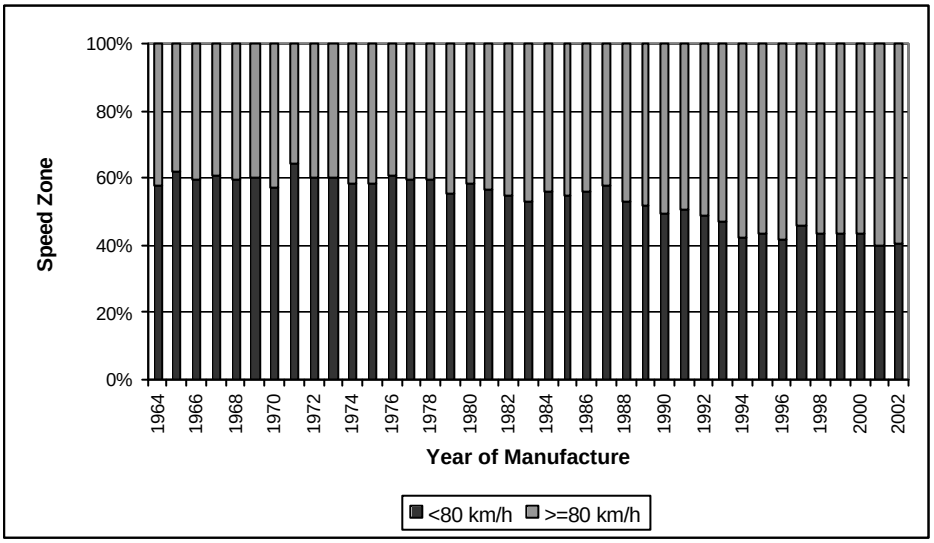
Used imported vehicles

Speed zone distribution by year of manufacture

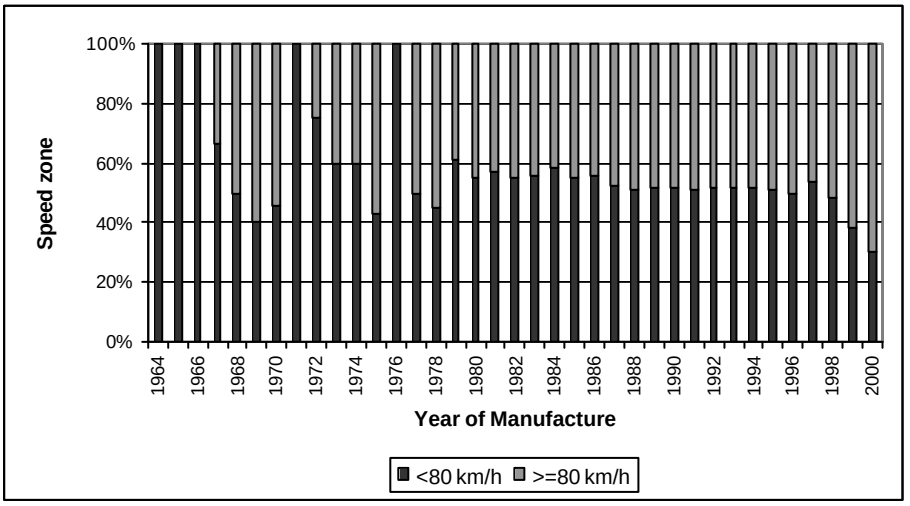
(Drivers Injured in Crashes in New Zealand)



All vehicles



New vehicles



Used imported vehicle

APPENDIX 2

DATA FREQUENCY FOR EACH YEAR OF VEHICLE MANUFACTURE FOR VEHICLES INVOLVED IN NEW ZEALAND CRASHES DURING 1991-2002

FREQUENCY FOR EACH YEAR OF MANUFACTURE FOR ALL TYPES OF CRASHES FOR ALL VEHICLES

Year of Manufacture	No. of uninjured drivers in NZ (91-2002)	No. of injured drivers in NZ (91-2002)	No. of involved drivers in NZ (91-2002)	No. of injured (but not severely) drivers in NZ (91-2002)	No. of severely injured drivers in NZ (91-2002)	No. of injured drivers in NZ (91-2002)	Analysis Inclusion Criteria Inv=100 Inj=20
1964	95	29	124	26	16	42	0
1965	96	34	130	24	18	42	0
1966	103	33	136	32	25	57	0
1967	118	50	168	34	28	62	0
1968	167	53	220	44	39	83	0
1969	253	83	336	52	44	96	0
1970	397	123	520	116	81	197	1
1971	511	132	643	129	93	222	1
1972	824	194	1018	222	192	414	1
1973	873	236	1109	237	175	412	1
1974	1082	305	1387	307	215	522	1
1975	892	277	1169	237	181	418	1
1976	1066	277	1343	260	197	457	1
1977	893	244	1137	234	177	411	1
1978	1238	363	1601	343	271	614	1
1979	1537	434	1971	418	312	730	1
1980	1923	516	2439	542	440	982	1
1981	2535	758	3293	741	635	1376	1
1982	3011	866	3877	834	718	1552	1
1983	3237	872	4109	844	783	1627	1
1984	4263	1049	5312	1237	1006	2243	1
1985	3675	878	4553	1040	863	1903	1
1986	3463	780	4243	1069	892	1961	1
1987	3248	775	4023	1044	836	1880	1
1988	3180	750	3930	1056	834	1890	1
1989	3806	874	4680	1382	991	2373	1
1990	3488	871	4359	1324	991	2315	1
1991	2722	633	3355	1022	721	1743	1
1992	2376	542	2918	914	676	1590	1
1993	1885	428	2313	735	548	1283	1
1994	1697	410	2107	738	481	1219	1
1995	1174	263	1437	471	327	798	1
1996	983	230	1213	369	319	688	1
1997	710	130	840	284	208	492	1
1998	485	125	610	194	163	357	1
1999	420	89	509	200	122	322	1
2000	294	67	361	155	101	256	1
2001	186	43	229	98	56	154	1
2002	75	12	87	42	24	66	0
Total	**58981**	**14828**	**73809**	**19050**	**14799**	**33849**	**32**

APPENDIX 3

CRASHWORTHINESS, INJURY RISK AND INJURY SEVERITY ESTIMATES BY YEAR OF VEHICLE MANUFACTURE

CRASHWORTHINESS INJURY RISK BY YEAR OF MANUFACTURE FOR ALL VEHICLES

Year of Manufacture	Coefficient of Car Model	Standard Error of Coefficient	Pr(Risk) %	Lower 95% Confidence Limit	Upper 95% Confidence Limit	Width of Confidence Interval
AVERAGE YEAR	**-0.2525**		**43.72**			
1964	0.0052	0.3217	43.85	29.36	59.46	30.10
1965	0.1680	0.3156	47.89	33.11	63.04	29.93
1966	0.2337	0.2710	49.53	36.59	62.54	25.95
1967	0.3471	0.2568	52.36	39.92	64.52	24.60
1968	0.2295	0.2251	49.42	38.60	60.30	21.71
1969	0.3567	0.2085	52.60	42.45	62.55	20.10
1970	0.0938	0.1481	46.04	38.96	53.28	14.32
1971	0.1178	0.1398	46.64	39.92	53.48	13.55
1972	0.2833	0.1026	50.77	45.75	55.77	10.02
1973	0.2059	0.1037	48.84	43.79	53.91	10.12
1974	0.1542	0.0931	47.54	43.03	52.10	9.08
1975	0.2472	0.1024	49.87	44.87	54.87	10.00
1976	0.1980	0.0986	48.64	43.84	53.46	9.63
1977	0.1874	0.1033	48.37	43.35	53.43	10.08
1978	0.2306	0.0856	49.45	45.27	53.64	8.37
1979	0.1157	0.0793	46.59	42.75	50.47	7.72
1980	0.1590	0.0690	47.66	44.31	51.04	6.74
1981	0.1815	0.0595	48.23	45.32	51.14	5.82
1982	0.1861	0.0565	48.34	45.58	51.11	5.53
1983	0.2293	0.0554	49.42	46.71	52.13	5.42
1984	0.0788	0.0487	45.67	43.31	48.04	4.73
1985	0.0820	0.0519	45.75	43.24	48.28	5.05
1986	0.0737	0.0512	45.54	43.07	48.04	4.97
1987	0.0133	0.0522	44.05	41.54	46.58	5.04
1988	-0.0468	0.0523	42.57	40.09	45.10	5.01
1989	-0.1358	0.0480	40.41	38.17	42.70	4.53
1990	-0.1097	0.0484	41.04	38.77	43.36	4.59
1991	-0.2095	0.0546	38.65	36.15	41.22	5.07
1992	-0.1904	0.0567	39.10	36.49	41.78	5.29
1993	-0.1741	0.0621	39.49	36.63	42.44	5.81
1994	-0.3459	0.0642	35.47	32.65	38.40	5.75
1995	-0.2993	0.0771	36.54	33.12	40.11	7.00
1996	-0.1059	0.0816	41.13	37.32	45.05	7.73
1997	-0.3246	0.0962	35.96	31.74	40.41	8.66
1998	-0.1780	0.1110	39.40	34.34	44.70	10.35
1999	-0.5273	0.1197	31.44	26.61	36.70	10.09
2000	-0.4453	0.1328	33.23	27.73	39.23	11.51
2001	-0.5343	0.1720	31.29	24.53	38.94	14.42
2002	-0.5509	0.2612	30.93	21.16	42.76	21.61

CRASHWORTHINESS INJURY SEVERITY BY YEAR OF VEHICLE MANUFACTURE FOR ALL VEHICLES

Year of Manufacture	Coefficient of Car Model	Standard Error of Coefficient	Pr(Severity) %	Lower 95% Confidence Limit	Upper 95% Confidence Limit	Width of Confidence Interval
AVERAGE	**-1.3807**		**20.09**			
YEAR						
1964	0.1992	0.2124	23.48	16.83	31.75	14.92
1965	0.4278	0.2004	27.83	20.66	36.35	15.69
1966	0.2678	0.2004	24.73	18.16	32.74	14.58
1967	0.5516	0.1701	30.38	23.82	37.86	14.03
1968	0.2263	0.1585	23.97	18.77	30.07	11.31
1969	0.2954	0.1281	25.25	20.81	30.28	9.46
1970	0.1918	0.1047	23.35	19.88	27.22	7.34
1971	0.0764	0.0992	21.34	18.26	24.79	6.53
1972	-0.0503	0.0818	19.29	16.92	21.91	4.99
1973	0.1199	0.0760	22.08	19.63	24.75	5.13
1974	0.1384	0.0676	22.40	20.18	24.79	4.61
1975	0.2537	0.0714	24.47	21.98	27.15	5.17
1976	0.0826	0.0700	21.45	19.23	23.85	4.62
1977	0.1271	0.0745	22.21	19.79	24.83	5.04
1978	0.2068	0.0627	23.62	21.47	25.90	4.43
1979	0.1416	0.0574	22.46	20.56	24.48	3.92
1980	0.0947	0.0529	21.65	19.95	23.46	3.52
1981	0.2090	0.0454	23.65	22.09	25.30	3.21
1982	0.1647	0.0427	22.86	21.42	24.37	2.95
1983	0.0869	0.0423	21.52	20.15	22.95	2.80
1984	0.0034	0.0389	20.14	18.95	21.40	2.45
1985	-0.0405	0.0416	19.45	18.20	20.76	2.55
1986	-0.0952	0.0435	18.60	17.35	19.93	2.58
1987	-0.0438	0.0438	19.40	18.09	20.77	2.68
1988	-0.1096	0.0444	18.39	17.12	19.73	2.61
1989	-0.1276	0.0416	18.12	16.94	19.36	2.42
1990	-0.0812	0.0420	18.82	17.59	20.11	2.52
1991	-0.1365	0.0478	17.99	16.65	19.41	2.76
1992	-0.1604	0.0512	17.64	16.23	19.14	2.92
1993	-0.1721	0.0568	17.47	15.92	19.13	3.21
1994	-0.1389	0.0584	17.95	16.33	19.70	3.37
1995	-0.2246	0.0709	16.72	14.88	18.75	3.87
1996	-0.2278	0.0760	16.68	14.71	18.85	4.14
1997	-0.4669	0.0972	13.62	11.53	16.02	4.49
1998	-0.1405	0.1027	17.93	15.16	21.08	5.93
1999	-0.3990	0.1184	14.43	11.80	17.54	5.75
2000	-0.3245	0.1370	15.38	12.20	19.21	7.01
2001	-0.2932	0.1705	15.79	11.84	20.76	8.92
2002	-0.6326	0.3093	11.78	6.79	19.67	12.88

CRASHWORTHINESS BY YEAR OF VEHICLE MANUFACTURE FOR ALL VEHICLES

Year of Manufacture	Pr(Risk) %	Pr(Severity) %	Serious injury rate per 100 drivers involved	Overall rank order	Lower 95% Confidence Limit	Upper 95% Confidence Limit	Width of Confidence Interval
AVERAGE YEAR	**43.72**	**20.09**	**8.78**				
1964	43.85	23.48	10.29	22	6.39	16.58	10.18
1965	47.89	27.83	13.33	38	8.68	20.47	11.80
1966	49.53	24.73	12.25	36	8.22	18.26	10.04
1967	52.36	30.38	15.91	39	11.40	22.21	10.82
1968	49.42	23.97	11.85	34	8.56	16.39	7.83
1969	52.60	25.25	13.28	37	10.14	17.39	7.25
1970	46.04	23.35	10.75	29	8.61	13.42	4.81
1971	46.64	21.34	9.95	21	8.06	12.30	4.24
1972	50.77	19.29	9.80	20	8.32	11.53	3.21
1973	48.84	22.08	10.78	30	9.23	12.60	3.37
1974	47.54	22.40	10.65	27	9.26	12.26	3.00
1975	49.87	24.47	12.20	35	10.55	14.12	3.57
1976	48.64	21.45	10.43	24	9.01	12.08	3.07
1977	48.37	22.21	10.74	28	9.21	12.54	3.33
1978	49.45	23.62	11.68	33	10.29	13.25	2.96
1979	46.59	22.46	10.46	25	9.28	11.80	2.53
1980	47.66	21.65	10.32	23	9.27	11.49	2.23
1981	48.23	23.65	11.41	32	10.42	12.49	2.08
1982	48.34	22.86	11.05	31	10.14	12.05	1.91
1983	49.42	21.52	10.64	26	9.77	11.58	1.81
1984	45.67	20.14	9.20	19	8.49	9.97	1.47
1985	45.75	19.45	8.90	18	8.17	9.69	1.53
1986	45.54	18.60	8.47	16	7.76	9.26	1.50
1987	44.05	19.40	8.54	17	7.81	9.35	1.54
1988	42.57	18.39	7.83	15	7.14	8.58	1.45
1989	40.41	18.12	7.32	13	6.71	7.99	1.28
1990	41.04	18.82	7.72	14	7.08	8.43	1.35
1991	38.65	17.99	6.95	11	6.28	7.69	1.41
1992	39.10	17.64	6.90	9	6.20	7.67	1.48
1993	39.49	17.47	6.90	10	6.13	7.76	1.63
1994	35.47	17.95	6.37	7	5.62	7.21	1.59
1995	36.54	16.72	6.11	6	5.26	7.10	1.84
1996	41.13	16.68	6.86	8	5.87	8.02	2.15
1997	35.96	13.62	4.90	3	3.99	6.00	2.01
1998	39.40	17.93	7.06	12	5.72	8.73	3.01
1999	31.44	14.43	4.54	2	3.51	5.86	2.34
2000	33.23	15.38	5.11	5	3.84	6.80	2.96
2001	31.29	15.79	4.94	4	3.43	7.11	3.68
2002	30.93	11.78	3.64	1	1.92	6.92	5.00

APPENDIX 4

DATA FREQUENCY FOR CRASHWORTHINESS BY YEAR OF MANUFACTURE FOR VEHICLES SOLD NEW IN NEW ZEALAND AND INVOLVED CRASHES DURING 1991-2002

FREQUENCY FOR EACH YEAR OF MANUFACTURE FOR ALL TYPES OF CRASHES FOR VEHICLES SOLD NEW IN NEW ZEALAND

Year of Manufacture	No. of uninjured drivers in NZ (91-2002)	No. of injured drivers in NZ (91-2002)	No. of involved drivers in NZ (91-2002)	No. of injured (but not severely) drivers in NZ (91-2002)	No. of severely injured drivers in NZ (91-2002)	No. of injured drivers in NZ (91-2002)	Analysis Inclusion Criteria Inv=100 Inj=20
1964	58	16	74	18	7	25	0
1965	74	18	92	17	12	29	0
1966	88	31	119	21	16	37	0
1967	74	33	107	18	15	33	0
1968	115	41	156	23	23	46	0
1969	180	58	238	28	27	55	0
1970	284	95	379	70	39	109	1
1971	405	97	502	82	63	145	1
1972	561	137	698	139	115	254	1
1973	684	172	856	169	108	277	1
1974	786	216	1002	190	149	339	1
1975	741	210	951	161	135	296	1
1976	748	212	960	153	134	287	1
1977	776	210	986	170	119	289	1
1978	970	253	1223	220	191	411	1
1979	1156	301	1457	295	217	512	1
1980	1410	346	1756	379	276	655	1
1981	1763	496	2259	479	381	860	1
1982	1885	518	2403	482	394	876	1
1983	1724	415	2139	453	379	832	1
1984	2178	482	2660	604	479	1083	1
1985	1903	425	2328	482	414	896	1
1986	1700	353	2053	481	400	881	1
1987	1735	373	2108	491	397	888	1
1988	1515	327	1842	460	355	815	1
1989	1747	389	2136	571	427	998	1
1990	1665	386	2051	579	429	1008	1
1991	1051	228	1279	382	261	643	1
1992	930	206	1136	387	263	650	1
1993	903	216	1119	389	271	660	1
1994	930	230	1160	429	257	686	1
1995	617	167	784	269	175	444	1
1996	544	142	686	240	205	445	1
1997	482	78	560	192	144	336	1
1998	285	84	369	102	112	214	1
1999	319	70	389	148	96	244	1
2000	262	59	321	143	92	235	1
2001	172	39	211	93	50	143	1
2002	73	13	86	38	23	61	0
Total	**33493**	**8142**	**41635**	**10047**	**7650**	**17697**	**32**

APPENDIX 5

CRASHWORTHINESS, INJURY RISK AND INJURY SEVERITY ESTIMATES BY YEAR OF VEHICLE MANUFACTURE FOR VEHICLES SOLD NEW IN NEW ZEALAND

CRASHWORTHINESS INJURY RISK BY YEAR OF MANUFACTURE FOR VEHICLES SOLD NEW IN NEW ZEALAND

Year of Manufacture	Coefficient of Car Model	Standard Error of Coefficient	Pr(Risk) %	Lower 95% Confidence Limit	Upper 95% Confidence Limit	Width of Confidence Interval
AVERAGE YEAR	**-0.2726**		**43.23**			
1964	-0.3380	0.4525	35.19	18.28	56.86	38.58
1965	-0.0792	0.3909	41.30	24.64	60.21	35.57
1966	0.1797	0.3404	47.68	31.86	63.98	32.11
1967	0.3637	0.3483	52.28	35.63	68.43	32.81
1968	0.4935	0.3023	55.50	40.82	69.28	28.47
1969	0.5044	0.2769	55.77	42.29	68.45	26.16
1970	-0.0594	0.2038	41.78	32.49	51.69	19.20
1971	0.3313	0.1721	51.47	43.08	59.77	16.69
1972	0.3205	0.1316	51.20	44.77	57.59	12.82
1973	0.1031	0.1286	45.77	39.62	52.06	12.45
1974	0.3564	0.1154	52.09	46.45	57.69	11.24
1975	0.3897	0.1214	52.92	46.98	58.78	11.80
1976	0.4094	0.1237	53.42	47.36	59.37	12.01
1977	0.1806	0.1245	47.70	41.68	53.79	12.12
1978	0.3530	0.1046	52.01	46.89	57.09	10.20
1979	0.1154	0.0956	46.08	41.47	50.76	9.28
1980	0.0501	0.0857	44.46	40.36	48.64	8.28
1981	0.1316	0.0756	46.48	42.82	50.18	7.36
1982	0.1590	0.0749	47.16	43.53	50.83	7.30
1983	0.1527	0.0766	47.01	43.29	50.76	7.47
1984	0.0481	0.0685	44.41	41.13	47.75	6.62
1985	0.1145	0.0739	46.06	42.48	49.67	7.18
1986	0.0863	0.0744	45.36	41.77	48.99	7.22
1987	0.0446	0.0744	44.33	40.76	47.95	7.19
1988	-0.0263	0.0775	42.58	38.92	46.33	7.41
1989	-0.0543	0.0713	41.90	38.54	45.34	6.79
1990	-0.0588	0.0709	41.79	38.45	45.20	6.75
1991	-0.2119	0.0869	38.12	34.19	42.21	8.02
1992	-0.2603	0.0864	36.98	33.13	41.01	7.88
1993	-0.2441	0.0856	37.36	33.53	41.37	7.84
1994	-0.4315	0.0853	33.09	29.50	36.89	7.39
1995	-0.4186	0.1032	33.38	29.04	38.02	8.98
1996	-0.1432	0.1017	39.75	35.09	44.61	9.52
1997	-0.3784	0.117	34.28	29.31	39.61	10.30
1998	0.0172	0.1432	43.65	36.91	50.63	13.72
1999	-0.5086	0.1383	31.41	25.88	37.52	11.64
2000	-0.4683	0.1410	32.28	26.56	38.59	12.03
2001	-0.6461	0.1819	28.52	21.84	36.31	14.47
2002	-0.5776	0.2712	29.94	20.07	42.10	22.03

CRASHWORTHINESS INJURY SEVERITY BY YEAR OF VEHICLE MANUFACTURE FOR VEHICLES SOLD NEW IN NEW ZEALAND

Year of Manufacture	Coefficient of Car Model	Standard Error of Coefficient	Pr(Severity) %	Lower 95% Confidence Limit	Upper 95% Confidence Limit	Width of Confidence Interval
AVERAGE YEAR	**-1.414**		**19.56**			
1964	0.1780	0.2821	22.51	14.32	33.55	19.23
1965	0.0067	0.2620	19.66	12.77	29.03	16.25
1966	0.3999	0.2097	26.61	19.38	35.36	15.98
1967	0.6642	0.2106	32.08	23.81	41.65	17.83
1968	0.4356	0.1835	27.31	20.78	35.00	14.22
1969	0.3788	0.1527	26.20	20.84	32.38	11.55
1970	0.3251	0.1204	25.18	21.00	29.88	8.88
1971	0.0687	0.1149	20.66	17.21	24.59	7.38
1972	0.0509	0.0977	20.37	17.44	23.65	6.21
1973	0.0959	0.0882	21.11	18.37	24.13	5.76
1974	0.1670	0.0801	22.32	19.71	25.16	5.44
1975	0.1952	0.0813	22.81	20.13	25.74	5.61
1976	0.2147	0.0810	23.15	20.45	26.10	5.65
1977	0.1897	0.0808	22.71	20.05	25.61	5.56
1978	0.1495	0.0740	22.01	19.63	24.61	4.98
1979	0.1063	0.0682	21.28	19.13	23.61	4.48
1980	0.0424	0.0637	20.23	18.29	22.32	4.03
1981	0.1799	0.0553	22.54	20.71	24.49	3.78
1982	0.1513	0.0541	22.05	20.28	23.92	3.64
1983	-0.0133	0.0586	19.35	17.62	21.20	3.58
1984	-0.0749	0.0545	18.40	16.85	20.06	3.21
1985	-0.0743	0.0575	18.41	16.78	20.17	3.39
1986	-0.1584	0.062	17.18	15.52	18.98	3.46
1987	-0.1075	0.0607	17.92	16.24	19.74	3.50
1988	-0.1618	0.0644	17.13	15.42	19.00	3.59
1989	-0.1466	0.0598	17.35	15.73	19.10	3.36
1990	-0.1128	0.0602	17.84	16.18	19.64	3.46
1991	-0.1894	0.0760	16.75	14.77	18.93	4.16
1992	-0.1793	0.0798	16.89	14.80	19.20	4.39
1993	-0.1437	0.0788	17.39	15.28	19.73	4.44
1994	-0.1574	0.0768	17.20	15.16	19.45	4.29
1995	-0.1047	0.0902	17.96	15.50	20.71	5.21
1996	-0.1404	0.0974	17.44	14.86	20.36	5.50
1997	-0.6292	0.1239	11.47	9.23	14.18	4.95
1998	-0.0278	0.1277	19.12	15.55	23.29	7.75
1999	-0.3778	0.1352	14.28	11.33	17.84	6.51
2000	-0.3265	0.1470	14.92	11.62	18.96	7.34
2001	-0.3427	0.1796	14.72	10.82	19.70	8.88
2002	-0.5311	0.3014	12.51	7.34	20.51	13.17

CRASHWORTHINESS BY YEAR OF VEHICLE MANUFACTURE FOR VEHICLES SOLD NEW IN NEW ZEALAND

Year of Manufacture	Pr(Risk) %	Pr(Severity) %	Serious injury rate per 100 drivers involved	Overall rank order	Lower 95% Confidence Limit	Upper 95% Confidence Limit	Width of Confidence Interval
AVERAGE YEAR	**43.23**	**19.56**	**8.45**				
1964	35.19	22.51	7.92	16	3.87	16.22	12.36
1965	41.30	19.66	8.12	18	4.41	14.95	10.54
1966	47.68	26.61	12.69	36	8.00	20.13	12.13
1967	52.28	32.08	16.77	39	10.91	25.78	14.86
1968	55.50	27.31	15.16	38	10.46	21.98	11.52
1969	55.77	26.20	14.61	37	10.55	20.25	9.70
1970	41.78	25.18	10.52	29	7.85	14.08	6.23
1971	51.47	20.66	10.63	30	8.34	13.55	5.20
1972	51.20	20.37	10.43	27	8.56	12.71	4.15
1973	45.77	21.11	9.66	24	7.97	11.72	3.75
1974	52.09	22.32	11.63	33	9.88	13.69	3.81
1975	52.92	22.81	12.07	34	10.22	14.26	4.04
1976	53.42	23.15	12.37	35	10.47	14.61	4.13
1977	47.70	22.71	10.83	31	9.08	12.93	3.85
1978	52.01	22.01	11.45	32	9.86	13.30	3.45
1979	46.08	21.28	9.81	25	8.48	11.35	2.87
1980	44.46	20.23	9.00	22	7.85	10.31	2.46
1981	46.48	22.54	10.48	28	9.33	11.76	2.43
1982	47.16	22.05	10.40	26	9.28	11.65	2.36
1983	47.01	19.35	9.09	23	8.05	10.28	2.23
1984	44.41	18.40	8.17	19	7.29	9.17	1.88
1985	46.06	18.41	8.48	21	7.52	9.57	2.05
1986	45.36	17.18	7.79	15	6.85	8.86	2.01
1987	44.33	17.92	7.94	17	7.00	9.02	2.02
1988	42.58	17.13	7.30	13	6.37	8.36	1.99
1989	41.90	17.35	7.27	12	6.41	8.25	1.84
1990	41.79	17.84	7.46	14	6.57	8.46	1.89
1991	38.12	16.75	6.38	9	5.42	7.51	2.09
1992	36.98	16.89	6.25	8	5.28	7.39	2.11
1993	37.36	17.39	6.50	10	5.51	7.67	2.16
1994	33.09	17.20	5.69	6	4.81	6.73	1.92
1995	33.38	17.96	5.99	7	4.92	7.31	2.39
1996	39.75	17.44	6.93	11	5.69	8.45	2.77
1997	34.28	11.47	3.93	2	3.02	5.11	2.09
1998	43.65	19.12	8.35	20	6.46	10.79	4.34
1999	31.41	14.28	4.49	4	3.34	6.02	2.67
2000	32.28	14.92	4.82	5	3.54	6.56	3.02
2001	28.52	14.72	4.20	3	2.83	6.22	3.39
2002	29.94	12.51	3.74	1	1.98	7.08	5.10

APPENDIX 6

DATA FREQUENCY FOR CRASHWORTHINESS BY YEAR OF MANUFACTURE FOR USED IMPORT VEHICLES INVOLVED IN NEW ZEALAND CRASHES DURING 1991-2002

FREQUENCY FOR EACH YEAR OF MANUFACTURE FOR ALL TYPES OF CRASHES FOR USED IMPORT VEHICLES

Year of Manufacture	No. of uninjured drivers in NZ (91-2002)	No. of injured drivers in NZ (91-2002)	No. of involved drivers in NZ (91-2002)	No. of injured (but not severely) drivers in NZ (91-2002)	No. of severely injured drivers in NZ (91-2002)	No. of injured drivers in NZ (91-2002)	Analysis Inclusion Criteria Inv=100 Inj=20
1964	1	0	1	1	0	1	0
1965	1	0	1	1	0	1	0
1966	0	0	0	0	0	0	0
1967	1	0	1	0	0	0	0
1968	1	0	1	2	0	2	0
1969	1	1	2	2	0	2	0
1970	5	1	6	1	0	1	0
1971	2	0	2	1	0	1	0
1972	1	1	2	3	0	3	0
1973	3	0	3	0	0	0	0
1974	4	1	5	1	1	2	0
1975	5	1	6	4	1	5	0
1976	6	2	8	2	1	3	0
1977	9	0	9	2	2	4	0
1978	41	23	64	12	13	25	0
1979	98	28	126	38	30	68	0
1980	236	63	299	78	55	133	1
1981	381	102	483	109	82	191	1
1982	712	186	898	213	163	376	1
1983	1049	274	1323	266	235	501	1
1984	1309	310	1619	365	269	634	1
1985	1219	282	1501	383	255	638	1
1986	1132	248	1380	373	268	641	1
1987	1010	242	1252	354	250	604	1
1988	1295	305	1600	456	325	781	1
1989	1387	319	1706	538	346	884	1
1990	1230	295	1525	489	330	819	1
1991	1104	274	1378	412	290	702	1
1992	1026	218	1244	394	272	666	1
1993	717	144	861	243	179	422	1
1994	529	122	651	201	149	350	1
1995	331	57	388	114	89	203	1
1996	177	45	222	54	47	101	1
1997	74	14	88	31	23	54	0
1998	28	2	30	13	8	21	0
1999	7	1	8	3	2	5	0
2000	5	1	6	3	1	4	0
2001	0	0	0	2	0	2	0
2002	0	0	0	0	0	0	0
Total	**15137**	**3562**	**18699**	**5164**	**3686**	**8850**	**17**

APPENDIX 7

CRASHWORTHINESS, INJURY RISK AND INJURY SEVERITY ESTIMATES BY YEAR OF VEHICLE MANUFACTURE FOR USED IMPORT VEHICLES

CRASHWORTHINESS INJURY RISK BY YEAR OF MANUFACTURE FOR USED IMPORT VEHICLES

Year of Manufacture	Coefficient of Car Model	Standard Error of Coefficient	Pr(Risk) %	Lower 95% Confidence Limit	Upper 95% Confidence Limit	Width of Confidence Interval
AVERAGE YEAR	**-0.3339**		**41.73**			
1978	0.6051	0.3982	56.74	37.54	74.11	36.57
1979	0.3606	0.2457	50.67	38.82	62.44	23.62
1980	0.1822	0.1790	46.21	37.69	54.96	17.27
1981	0.2155	0.1511	47.04	39.78	54.43	14.65
1982	0.2401	0.1131	47.66	42.18	53.19	11.01
1983	0.2966	0.0994	49.07	44.22	53.93	9.71
1984	0.1126	0.0913	44.49	40.13	48.94	8.82
1985	-0.0380	0.0908	40.81	36.59	45.17	8.58
1986	-0.0144	0.0895	41.38	37.20	45.69	8.49
1987	-0.0482	0.0915	40.56	36.32	44.95	8.63
1988	-0.0908	0.0827	39.54	35.74	43.47	7.74
1989	-0.1951	0.0794	37.07	33.52	40.77	7.25
1990	-0.1735	0.0817	37.58	33.90	41.40	7.50
1991	-0.1655	0.0869	37.77	33.86	41.85	7.99
1992	-0.2015	0.0890	36.93	32.96	41.07	8.11
1993	-0.1661	0.1068	37.75	32.97	42.78	9.81
1994	-0.1770	0.1157	37.50	32.35	42.94	10.59
1995	-0.1416	0.1464	38.33	31.81	45.30	13.49
1996	-0.0071	0.2022	41.56	32.36	51.38	19.02
1997	-0.1761	0.2734	37.52	26.00	50.65	24.64
1998	-0.4177	0.4446	32.05	16.48	52.99	36.51

CRASHWORTHINESS INJURY SEVERITY BY YEAR OF VEHICLE MANUFACTURE FOR USED IMPORT VEHICLES

Year of Manufacture	Coefficient of Car Model	Standard Error of Coefficient	Pr(Severity) %	Lower 95% Confidence Limit	Upper 95% Confidence Limit	Width of Confidence Interval
AVERAGE YEAR	**-1.4459**		**19.06**			
1978	0.9145	0.2614	37.02	26.04	49.52	23.48
1979	0.3328	0.2148	24.73	17.74	33.36	15.62
1980	0.2390	0.1475	23.02	18.30	28.54	10.24
1981	0.2259	0.1196	22.79	18.93	27.18	8.25
1982	0.2287	0.0942	22.84	19.75	26.26	6.51
1983	0.2557	0.0820	23.32	20.57	26.32	5.75
1984	0.1223	0.0777	21.02	18.60	23.66	5.06
1985	0.0581	0.0796	19.98	17.60	22.59	4.99
1986	0.0103	0.0825	19.22	16.84	21.86	5.02
1987	0.0427	0.0836	19.73	17.26	22.45	5.19
1988	-0.00591	0.0774	18.97	16.75	21.41	4.67
1989	-0.0435	0.0760	18.40	16.27	20.74	4.47
1990	-0.0522	0.0784	18.27	16.09	20.68	4.59
1991	0.0177	0.0810	19.34	16.98	21.94	4.95
1992	-0.1671	0.0869	16.62	14.39	19.11	4.72
1993	-0.2372	0.1011	15.67	13.22	18.47	5.24
1994	-0.0958	0.1097	17.63	14.72	20.97	6.25
1995	-0.3549	0.1478	14.18	11.00	18.08	7.07
1996	0.0399	0.1709	19.69	14.92	25.52	10.60
1997	-0.2367	0.2890	15.68	9.54	24.67	15.13
1998	-1.2943	0.7038	6.06	1.60	20.41	18.81

CRASHWORTHINESS BY YEAR OF VEHICLE MANUFACTURE FOR USED IMPORT VEHICLES

Year of Manufacture	Pr(Risk) %	Pr(Severity) %	Serious injury rate per 100 drivers involved	Overall rank order	Lower 95% Confidence Limit	Upper 95% Confidence Limit	Width of Confidence Interval
AVERAGE YEAR	**41.73**	**19.06**	**7.95**				
1978	56.74	37.02	21.00	21	13.17	33.51	20.34
1979	50.67	24.73	12.53	20	8.43	18.62	10.19
1980	46.21	23.02	10.64	16	7.95	14.25	6.30
1981	47.04	22.79	10.72	17	8.44	13.62	5.19
1982	47.66	22.84	10.89	18	9.06	13.08	4.02
1983	49.07	23.32	11.44	19	9.77	13.41	3.64
1984	44.49	21.02	9.35	15	8.00	10.93	2.93
1985	40.81	19.98	8.15	13	6.92	9.60	2.68
1986	41.38	19.22	7.95	11	6.74	9.39	2.66
1987	40.56	19.73	8.00	12	6.76	9.48	2.72
1988	39.54	18.97	7.50	10	6.41	8.78	2.37
1989	37.07	18.40	6.82	7	5.84	7.97	2.14
1990	37.58	18.27	6.87	8	5.85	8.06	2.21
1991	37.77	19.34	7.30	9	6.18	8.62	2.44
1992	36.93	16.62	6.14	5	5.13	7.34	2.22
1993	37.75	15.67	5.92	4	4.79	7.31	2.53
1994	37.50	17.63	6.61	6	5.27	8.29	3.02
1995	38.33	14.18	5.43	2	4.00	7.37	3.37
1996	41.56	19.69	8.18	14	5.74	11.67	5.93
1997	37.52	15.68	5.88	3	3.28	10.54	7.26
1998	32.05	6.06	1.94	1	0.47	8.08	7.61

APPENDIX 8

DATA FREQUENCY BY YEAR OF FIRST VEHICLE REGISTRATION FOR USED IMPORT VEHICLES INVOLVED IN NEW ZEALAND CRASHES DURING 1991-2002

FREQUENCY BY FIRST YEAR OF REGISTRATION FOR USED IMPORT VEHICLES FOR ALL TYPES OF CRASHES

Year of first registration	No. of uninjured drivers in NZ (91-2002)	No. of injured drivers in NZ (91-2002)	No. of involved drivers in NZ (91-2002)	No. of injured (but not severely) drivers in NZ (91-2002)	No. of severely injured drivers in NZ (91-2002)	No. of injured drivers in NZ (91-2002)	Analysis Inclusion Criteria Inv=100 Inj=20
1964	1	0	1	1	0	1	0
1965	1	0	1	1	0	1	0
1966	0	0	0	0	0	0	0
1967	1	0	1	0	0	0	0
1968	1	0	1	2	0	2	0
1969	1	1	2	2	0	2	0
1970	5	1	6	1	0	1	0
1971	2	0	2	1	0	1	0
1972	1	1	2	3	0	3	0
1973	3	0	3	0	0	0	0
1974	4	1	5	1	1	2	0
1975	5	1	6	4	1	5	0
1976	6	2	8	2	1	3	0
1977	9	0	9	2	2	4	0
1978	41	23	64	12	13	25	0
1979	98	28	126	38	30	68	0
1980	236	63	299	78	55	133	1
1981	381	102	483	109	82	191	1
1982	712	186	898	213	163	376	1
1983	1049	274	1323	266	235	501	1
1984	1309	310	1619	365	269	634	1
1985	1219	282	1501	383	255	638	1
1986	1132	248	1380	373	268	641	1
1987	1010	242	1252	354	250	604	1
1988	1295	305	1600	456	325	781	1
1989	1387	319	1706	538	346	884	1
1990	1230	295	1525	489	330	819	1
1991	1104	274	1378	412	290	702	1
1992	1026	218	1244	394	272	666	1
1993	717	144	861	243	179	422	1
1994	529	122	651	201	149	350	1
1995	331	57	388	114	89	203	1
1996	177	45	222	54	47	101	1
1997	74	14	88	31	23	54	0
1998	28	2	30	13	8	21	0
1999	7	1	8	3	2	5	0
2000	5	1	6	3	1	4	0
2001	0	0	0	2	0	2	0
2002	0	0	0	0	0	0	0
Total	**15137**	**3562**	**18699**	**5164**	**3686**	**8850**	**17**

APPENDIX 9

CRASHWORTHINESS, INJURY RISK AND INJURY SEVERITY ESTIMATES BY YEAR OF FIRST VEHICLE REGISTRATION FOR USED IMPORT VEHICLES

CRASHWORTHINESS INJURY RISK BY YEAR OF FIRST VEHICLE REGISTRATION FOR USED IMPORT VEHICLES

Year of first registration	Coefficient of Car Model	Standard Error of Coefficient	Pr(Risk) %	Lower 95% Confidence Limit	Upper 95% Confidence Limit	Width of Confidence Interval
AVERAGE YEAR	**-0.3339**		**41.73**			
1978	0.6051	0.3982	56.74	37.54	74.11	36.57
1979	0.3606	0.2457	50.67	38.82	62.44	23.62
1980	0.1822	0.1790	46.21	37.69	54.96	17.27
1981	0.2155	0.1511	47.04	39.78	54.43	14.65
1982	0.2401	0.1131	47.66	42.18	53.19	11.01
1983	0.2966	0.0994	49.07	44.22	53.93	9.71
1984	0.1126	0.0913	44.49	40.13	48.94	8.82
1985	-0.0380	0.0908	40.81	36.59	45.17	8.58
1986	-0.0144	0.0895	41.38	37.20	45.69	8.49
1987	-0.0482	0.0915	40.56	36.32	44.95	8.63
1988	-0.0908	0.0827	39.54	35.74	43.47	7.74
1989	-0.1951	0.0794	37.07	33.52	40.77	7.25
1990	-0.1735	0.0817	37.58	33.90	41.40	7.50
1991	-0.1655	0.0869	37.77	33.86	41.85	7.99
1992	-0.2015	0.0890	36.93	32.96	41.07	8.11
1993	-0.1661	0.1068	37.75	32.97	42.78	9.81
1994	-0.1770	0.1157	37.50	32.35	42.94	10.59
1995	-0.1416	0.1464	38.33	31.81	45.30	13.49
1996	-0.0071	0.2022	41.56	32.36	51.38	19.02
1997	-0.1761	0.2734	37.52	26.00	50.65	24.64
1998	-0.4177	0.4446	32.05	16.48	52.99	36.51

CRASHWORTHINESS INJURY SEVERITY BY YEAR OF FIRST VEHICLE REGISTRATION FOR USED IMPORT VEHICLES

Year of first registration	Coefficient of Car Model	Standard Error of Coefficient	Pr(Severity) %	Lower 95% Confidence Limit	Upper 95% Confidence Limit	Width of Confidence Interval
AVERAGE YEAR	**-1.4459**		**19.06**			
1978	0.9145	0.2614	37.02	26.04	49.52	23.48
1979	0.3328	0.2148	24.73	17.74	33.36	15.62
1980	0.2390	0.1475	23.02	18.30	28.54	10.24
1981	0.2259	0.1196	22.79	18.93	27.18	8.25
1982	0.2287	0.0942	22.84	19.75	26.26	6.51
1983	0.2557	0.0820	23.32	20.57	26.32	5.75
1984	0.1223	0.0777	21.02	18.60	23.66	5.06
1985	0.0581	0.0796	19.98	17.60	22.59	4.99
1986	0.0103	0.0825	19.22	16.84	21.86	5.02
1987	0.0427	0.0836	19.73	17.26	22.45	5.19
1988	-0.00591	0.0774	18.97	16.75	21.41	4.67
1989	-0.0435	0.0760	18.40	16.27	20.74	4.47
1990	-0.0522	0.0784	18.27	16.09	20.68	4.59
1991	0.0177	0.0810	19.34	16.98	21.94	4.95
1992	-0.1671	0.0869	16.62	14.39	19.11	4.72
1993	-0.2372	0.1011	15.67	13.22	18.47	5.24
1994	-0.0958	0.1097	17.63	14.72	20.97	6.25
1995	-0.3549	0.1478	14.18	11.00	18.08	7.07
1996	0.0399	0.1709	19.69	14.92	25.52	10.60
1997	-0.2367	0.2890	15.68	9.54	24.67	15.13
1998	-1.2943	0.7038	6.06	1.60	20.41	18.81

CRASHWORTHINESS BY YEAR OF FIRST VEHICLE REGISTRATION FOR USED IMPORT VEHICLES

Year of first registration	Pr(Risk) %	Pr(Severity) %	Serious injury rate per 100 drivers involved	Overall rank order	Lower 95% Confidence Limit	Upper 95% Confidence Limit	Width of Confidence Interval
AVERAGE YEAR	**41.73**	**19.06**	**7.95**				
1978	56.74	37.02	21.00	21	13.17	33.51	20.34
1979	50.67	24.73	12.53	20	8.43	18.62	10.19
1980	46.21	23.02	10.64	16	7.95	14.25	6.30
1981	47.04	22.79	10.72	17	8.44	13.62	5.19
1982	47.66	22.84	10.89	18	9.06	13.08	4.02
1983	49.07	23.32	11.44	19	9.77	13.41	3.64
1984	44.49	21.02	9.35	15	8.00	10.93	2.93
1985	40.81	19.98	8.15	13	6.92	9.60	2.68
1986	41.38	19.22	7.95	11	6.74	9.39	2.66
1987	40.56	19.73	8.00	12	6.76	9.48	2.72
1988	39.54	18.97	7.50	10	6.41	8.78	2.37
1989	37.07	18.40	6.82	7	5.84	7.97	2.14
1990	37.58	18.27	6.87	8	5.85	8.06	2.21
1991	37.77	19.34	7.30	9	6.18	8.62	2.44
1992	36.93	16.62	6.14	5	5.13	7.34	2.22
1993	37.75	15.67	5.92	4	4.79	7.31	2.53
1994	37.50	17.63	6.61	6	5.27	8.29	3.02
1995	38.33	14.18	5.43	2	4.00	7.37	3.37
1996	41.56	19.69	8.18	14	5.74	11.67	5.93
1997	37.52	15.68	5.88	3	3.28	10.54	7.26
1998	32.05	6.06	1.94	1	0.47	8.08	7.61

APPENDIX 10

DATA FREQUENCY BY YEAR OF FIRST REGISTRATION FOR VEHICLES INVOLVED IN NEW ZEALAND CRASHES DURING 1991-2002

FREQUENCY BY YEAR OF FIRST REGISTRATION FOR ALL TYPES OF CRASHES FOR ALL VEHICLES

Year of first registration	No. of uninjured drivers in NZ (91-2002)	No. of injured drivers in NZ (91-2002)	No. of involved drivers in NZ (91-2002)	No. of injured (but not severely) drivers in NZ (91-2002)	No. of severely injured drivers in NZ (91-2002)	No. of injured drivers in NZ (91-2002)	Analysis Inclusion Criteria Inv=100 Inj=20
1964	95	29	124	26	16	42	0
1965	96	34	130	24	18	42	0
1966	103	33	136	32	25	57	0
1967	118	50	168	34	28	62	0
1968	167	53	220	44	39	83	0
1969	253	83	336	52	44	96	0
1970	397	123	520	116	81	197	1
1971	511	132	643	129	93	222	1
1972	824	194	1018	222	192	414	1
1973	873	236	1109	237	175	412	1
1974	1082	305	1387	307	215	522	1
1975	892	277	1169	237	181	418	1
1976	1066	277	1343	260	197	457	1
1977	893	244	1137	234	177	411	1
1978	1238	363	1601	343	271	614	1
1979	1537	434	1971	418	312	730	1
1980	1923	516	2439	542	440	982	1
1981	2535	758	3293	741	635	1376	1
1982	3011	866	3877	834	718	1552	1
1983	3237	872	4109	844	783	1627	1
1984	4263	1049	5312	1237	1006	2243	1
1985	3675	878	4553	1040	863	1903	1
1986	3463	780	4243	1069	892	1961	1
1987	3248	775	4023	1044	836	1880	1
1988	3180	750	3930	1056	834	1890	1
1989	3806	874	4680	1382	991	2373	1
1990	3488	871	4359	1324	991	2315	1
1991	2722	633	3355	1022	721	1743	1
1992	2376	542	2918	914	676	1590	1
1993	1885	428	2313	735	548	1283	1
1994	1697	410	2107	738	481	1219	1
1995	1174	263	1437	471	327	798	1
1996	983	230	1213	369	319	688	1
1997	710	130	840	284	208	492	1
1998	485	125	610	194	163	357	1
1999	420	89	509	200	122	322	1
2000	294	67	361	155	101	256	1
2001	186	43	229	98	56	154	1
2002	75	12	87	42	24	66	0
Total	**58981**	**14828**	**73809**	**19050**	**14799**	**33849**	**32**

APPENDIX 11

CRASHWORTHINESS, INJURY RISK AND INJURY SEVERITY ESTIMATES BY YEAR OF FIRST VEHICLE REGISTRATION FOR ALL VEHICLES

CRASHWORTHINESS INJURY RISK BY YEAR OF FIRST REGISTRATION FOR ALL VEHICLES

Year of first registration	Coefficient of Car Model	Standard Error of Coefficient	Pr(Risk) %	Lower 95% Confidence Limit	Upper 95% Confidence Limit	Width of Confidence Interval
AVERAGE YEAR	**-0.2525**		**43.72**			
1964	0.0052	0.3217	43.85	29.36	59.46	30.10
1965	0.1680	0.3156	47.89	33.11	63.04	29.93
1966	0.2337	0.2710	49.53	36.59	62.54	25.95
1967	0.3471	0.2568	52.36	39.92	64.52	24.60
1968	0.2295	0.2251	49.42	38.60	60.30	21.71
1969	0.3567	0.2085	52.60	42.45	62.55	20.10
1970	0.0938	0.1481	46.04	38.96	53.28	14.32
1971	0.1178	0.1398	46.64	39.92	53.48	13.55
1972	0.2833	0.1026	50.77	45.75	55.77	10.02
1973	0.2059	0.1037	48.84	43.79	53.91	10.12
1974	0.1542	0.0931	47.54	43.03	52.10	9.08
1975	0.2472	0.1024	49.87	44.87	54.87	10.00
1976	0.1980	0.0986	48.64	43.84	53.46	9.63
1977	0.1874	0.1033	48.37	43.35	53.43	10.08
1978	0.2306	0.0856	49.45	45.27	53.64	8.37
1979	0.1157	0.0793	46.59	42.75	50.47	7.72
1980	0.1590	0.069	47.66	44.31	51.04	6.74
1981	0.1815	0.0595	48.23	45.32	51.14	5.82
1982	0.1861	0.0565	48.34	45.58	51.11	5.53
1983	0.2293	0.0554	49.42	46.71	52.13	5.42
1984	0.0788	0.0487	45.67	43.31	48.04	4.73
1985	0.0820	0.0519	45.75	43.24	48.28	5.05
1986	0.0737	0.0512	45.54	43.07	48.04	4.97
1987	0.0133	0.0522	44.05	41.54	46.58	5.04
1988	-0.0468	0.0523	42.57	40.09	45.10	5.01
1989	-0.1358	0.0480	40.41	38.17	42.70	4.53
1990	-0.1097	0.0484	41.04	38.77	43.36	4.59
1991	-0.2095	0.0546	38.65	36.15	41.22	5.07
1992	-0.1904	0.0567	39.10	36.49	41.78	5.29
1993	-0.1741	0.0621	39.49	36.63	42.44	5.81
1994	-0.3459	0.0642	35.47	32.65	38.40	5.75
1995	-0.2993	0.0771	36.54	33.12	40.11	7.00
1996	-0.1059	0.0816	41.13	37.32	45.05	7.73
1997	-0.3246	0.0962	35.96	31.74	40.41	8.66
1998	-0.1780	0.1110	39.40	34.34	44.70	10.35
1999	-0.5273	0.1197	31.44	26.61	36.70	10.09
2000	-0.4453	0.1328	33.23	27.73	39.23	11.51
2001	-0.5343	0.1720	31.29	24.53	38.94	14.42
2002	-0.5509	0.2612	30.93	21.16	42.76	21.61

CRASHWORTHINESS INJURY SEVERITY BY YEAR OF FIRST REGISTRATION FOR ALL VEHICLES

Year of first registration	Coefficient of Car Model	Standard Error of Coefficient	Pr(Severity) %	Lower 95% Confidence Limit	Upper 95% Confidence Limit	Width of Confidence Interval
AVERAGE YEAR	**-1.3807**		**20.09**			
1964	0.1992	0.2124	23.48	16.83	31.75	14.92
1965	0.4278	0.2004	27.83	20.66	36.35	15.69
1966	0.2678	0.2004	24.73	18.16	32.74	14.58
1967	0.5516	0.1701	30.38	23.82	37.86	14.03
1968	0.2263	0.1585	23.97	18.77	30.07	11.31
1969	0.2954	0.1281	25.25	20.81	30.28	9.46
1970	0.1918	0.1047	23.35	19.88	27.22	7.34
1971	0.0764	0.0992	21.34	18.26	24.79	6.53
1972	-0.0503	0.0818	19.29	16.92	21.91	4.99
1973	0.1199	0.0760	22.08	19.63	24.75	5.13
1974	0.1384	0.0676	22.40	20.18	24.79	4.61
1975	0.2537	0.0714	24.47	21.98	27.15	5.17
1976	0.0826	0.0700	21.45	19.23	23.85	4.62
1977	0.1271	0.0745	22.21	19.79	24.83	5.04
1978	0.2068	0.0627	23.62	21.47	25.90	4.43
1979	0.1416	0.0574	22.46	20.56	24.48	3.92
1980	0.0947	0.0529	21.65	19.95	23.46	3.52
1981	0.2090	0.0454	23.65	22.09	25.30	3.21
1982	0.1647	0.0427	22.86	21.42	24.37	2.95
1983	0.0869	0.0423	21.52	20.15	22.95	2.80
1984	0.00336	0.0389	20.14	18.95	21.40	2.45
1985	-0.0405	0.0416	19.45	18.20	20.76	2.55
1986	-0.0952	0.0435	18.60	17.35	19.93	2.58
1987	-0.0438	0.0438	19.40	18.09	20.77	2.68
1988	-0.1096	0.0444	18.39	17.12	19.73	2.61
1989	-0.1276	0.0416	18.12	16.94	19.36	2.42
1990	-0.0812	0.0420	18.82	17.59	20.11	2.52
1991	-0.1365	0.0478	17.99	16.65	19.41	2.76
1992	-0.1604	0.0512	17.64	16.23	19.14	2.92
1993	-0.1721	0.0568	17.47	15.92	19.13	3.21
1994	-0.1389	0.0584	17.95	16.33	19.70	3.37
1995	-0.2246	0.0709	16.72	14.88	18.75	3.87
1996	-0.2278	0.0760	16.68	14.71	18.85	4.14
1997	-0.4669	0.0972	13.62	11.53	16.02	4.49
1998	-0.1405	0.1027	17.93	15.16	21.08	5.93
1999	-0.3990	0.1184	14.43	11.80	17.54	5.75
2000	-0.3245	0.1370	15.38	12.20	19.21	7.01
2001	-0.2932	0.1705	15.79	11.84	20.76	8.92
2002	-0.6326	0.3093	11.78	6.79	19.67	12.88

CRASHWORTHINESS BY YEAR OF FIRST REGISTRATION FOR ALL VEHICLES

Year of first registration	Pr(Risk) %	Pr(Severity) %	Serious injury rate per 100 drivers involved	Overall rank order	Lower 95% Confidence Limit	Upper 95% Confidence Limit	Width of Confidence Interval
AVERAGE YEAR	**43.72**	**20.09**	**8.78**				
1964	43.85	23.48	10.29	22	6.39	16.58	10.18
1965	47.89	27.83	13.33	38	8.68	20.47	11.80
1966	49.53	24.73	12.25	36	8.22	18.26	10.04
1967	52.36	30.38	15.91	39	11.40	22.21	10.82
1968	49.42	23.97	11.85	34	8.56	16.39	7.83
1969	52.60	25.25	13.28	37	10.14	17.39	7.25
1970	46.04	23.35	10.75	29	8.61	13.42	4.81
1971	46.64	21.34	9.95	21	8.06	12.30	4.24
1972	50.77	19.29	9.80	20	8.32	11.53	3.21
1973	48.84	22.08	10.78	30	9.23	12.60	3.37
1974	47.54	22.40	10.65	27	9.26	12.26	3.00
1975	49.87	24.47	12.20	35	10.55	14.12	3.57
1976	48.64	21.45	10.43	24	9.01	12.08	3.07
1977	48.37	22.21	10.74	28	9.21	12.54	3.33
1978	49.45	23.62	11.68	33	10.29	13.25	2.96
1979	46.59	22.46	10.46	25	9.28	11.80	2.53
1980	47.66	21.65	10.32	23	9.27	11.49	2.23
1981	48.23	23.65	11.41	32	10.42	12.49	2.08
1982	48.34	22.86	11.05	31	10.14	12.05	1.91
1983	49.42	21.52	10.64	26	9.77	11.58	1.81
1984	45.67	20.14	9.20	19	8.49	9.97	1.47
1985	45.75	19.45	8.90	18	8.17	9.69	1.53
1986	45.54	18.60	8.47	16	7.76	9.26	1.50
1987	44.05	19.40	8.54	17	7.81	9.35	1.54
1988	42.57	18.39	7.83	15	7.14	8.58	1.45
1989	40.41	18.12	7.32	13	6.71	7.99	1.28
1990	41.04	18.82	7.72	14	7.08	8.43	1.35
1991	38.65	17.99	6.95	11	6.28	7.69	1.41
1992	39.10	17.64	6.90	9	6.20	7.67	1.48
1993	39.49	17.47	6.90	10	6.13	7.76	1.63
1994	35.47	17.95	6.37	7	5.62	7.21	1.59
1995	36.54	16.72	6.11	6	5.26	7.10	1.84
1996	41.13	16.68	6.86	8	5.87	8.02	2.15
1997	35.96	13.62	4.90	3	3.99	6.00	2.01
1998	39.40	17.93	7.06	12	5.72	8.73	3.01
1999	31.44	14.43	4.54	2	3.51	5.86	2.34
2000	33.23	15.38	5.11	5	3.84	6.80	2.96
2001	31.29	15.79	4.94	4	3.43	7.11	3.68
2002	30.93	11.78	3.64	1	1.92	6.92	5.00